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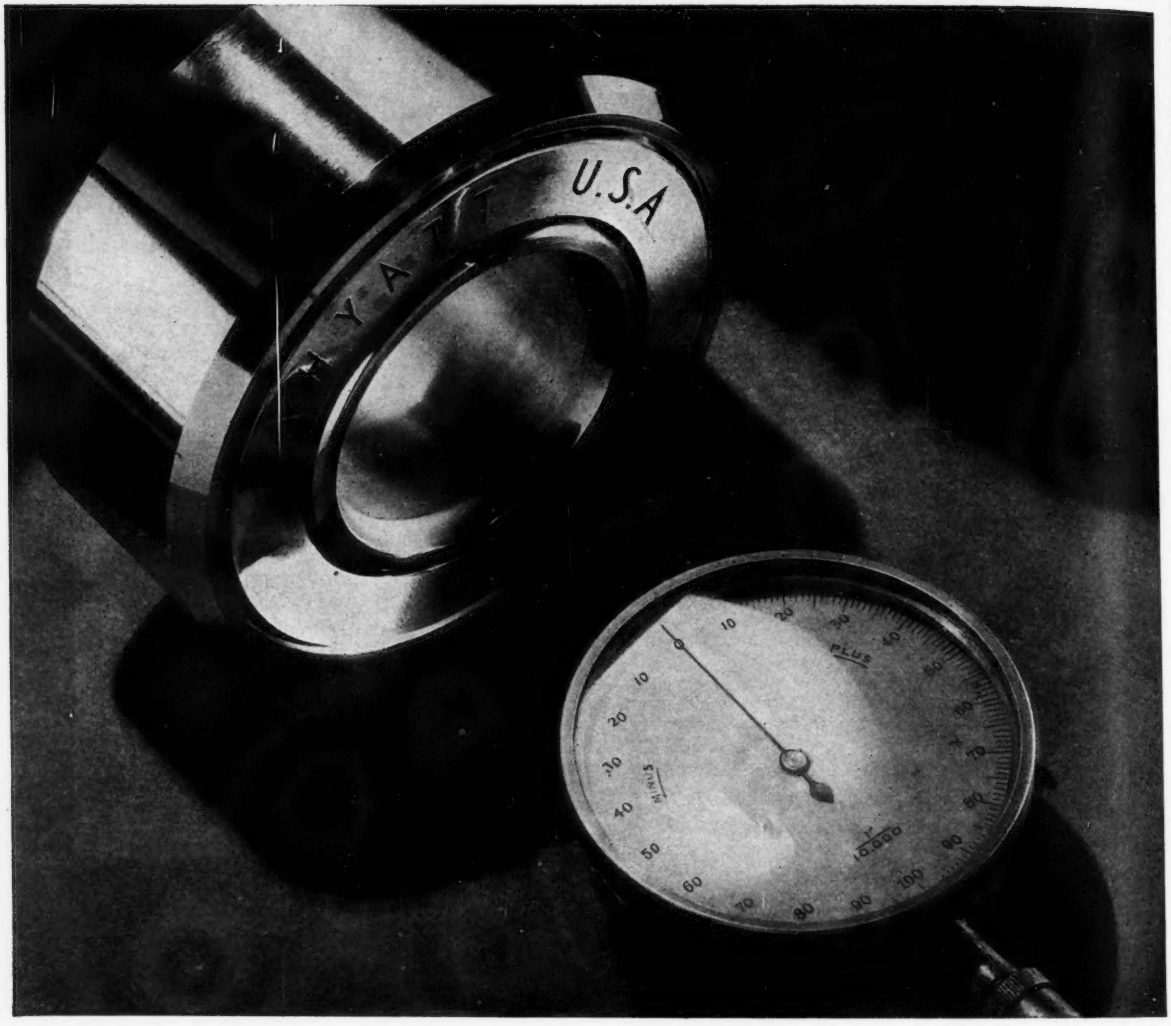

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AGRICULTURAL ENGINEERING

Volume 13 MAY, 1932 Number 5

Farm Building Losses in Iowa Due to Wind[1]

By Marvin F. Schweers[2]

THE Iowa Mutual Tornado Insurance Association and the Iowa Reinsurance Association are sponsoring a fellowship at Iowa State College to study wind and fire losses and to devise methods to decrease these losses.

During 1930-31 the study was on farm building losses in Iowa due to wind, and covered specifically (1) the extent of the losses to farm buildings in Iowa due to wind, (2) forces exerted by the air in motion with reference to farm buildings, and (3) structural details (tests).

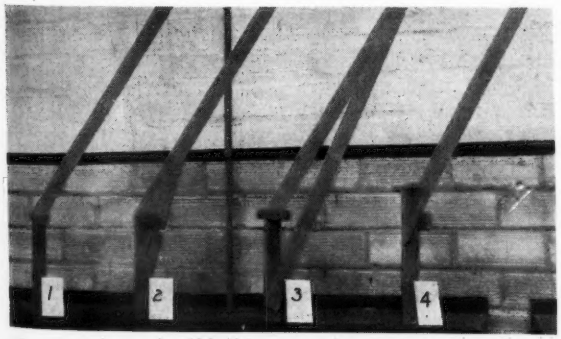
EXTENT OF LOSSES

Field and statistical studies of losses to farm buildings due to the wind were included. In the field study, observations were made of buildings damaged or demolished by the wind, in order to determine which members or portions of the buildings were the first to fail. Due to the fact that the major destructive storms occurred before this work had commenced, very little data have been collected on this particular phase. Numerous photographs of demolished buildings were available and these gave some suggestions as to the sequence of destruction of the structures. The statistical study consisted of a survey of the records of the Iowa Mutual Tornado Insurance Association for 1930. A correlation of the data was made by counties, determining the relation of insurance carried by this association to the farm building investment in Iowa; the distribution of losses for the year; the distribution of losses by months; and the ratio of claims paid to insurance in force, which showed the loss areas for the year. This phase of the study is not of great interest to a national group as it considers only Iowa, but there were several conclusions drawn which are here listed:

1. The greatest loss and proportional loss area for 1930 was in the northwest section of the state.
2. The largest losses were sustained in June with large losses in May and September.
3. The general direction of the wind causing these storms was from the west to the east.

[1]A paper presented at a meeting of the Structures Division session of the 25th annual meeting of the American Society of Agricultural Engineers, at Ames, Iowa, June 1931.

[2]Department of agricultural engineering, Iowa State College. (Now extension agricultural engineer, Michigan State College.) Assoc. Mem. A.S.A.E.



The model plate joints tested, showing differences in construction

Losses by items were also determined. Of the total of nearly $220,000 paid by the Iowa Mutual Tornado Insurance Association in 1930, over 60 per cent was on the following losses, which in many cases were due to poor design or faulty construction:

1. Nearly $80,000 for buildings demolished, of which over $41,000 was for barns.
2. Almost $27,000 for straightening and bracing buildings.
3. Over $18,000 for claims in which buildings had left their foundations and had to be moved back.
4. More than $11,000 on buildings having the roof blown off.
5. Nearly 1200 claims totaling almost $14,000 for replacing glass and screens, and over $14,000 for repairing machinery which had been damaged by falling buildings and debris.

It was evident from photographs of several demolished buildings showing the way the debris was piled, that a sequence of failures occurred. In most cases the leeward side of the structures had been the first portion to loosen. Many of these losses can be ascribed to the plate joint failing. Had this joint been better constructed a number of these catastrophes might have been averted.

Conclusions drawn from this study are as follows:

1. Field observations are essential in a study of this type in order that intelligent research may be carried on.
2. Many losses are apparently due to improper design and construction.
3. Many causes for losses can be ascribed to the failure of the plate joint on the leeward side of the building.
4. A great amount of research and study is necessary to determine (a) wind stresses on farm buildings, and (b) best methods of construction.

FORCES EXERTED BY AIR MOVEMENT

There are numerous formulas now used to determine wind pressures on buildings, but these were found to be inadequate for farm structures design. Plans are now drawn along traditional lines, using a large factor of safety, or, as one authority states, a "factor of ignorance."

Experiments have proven that there is a negative pressure (below normal atmospheric), or suction, created by wind action, which must be considered in building design. This is especially true of wood joints when the tension and compression strengths differ greatly. Duchemin's formula, which is used extensively in structural design, does not consider this factor, nor does Hutton's formula. Laugley's experiments conform very closely to calculated values of Duchemin's formula. The formula $P = KAV^2$ is still used for wind pressure on vertical walls normal to the wind, but it considers only the windward side of these structures.

Considering that these formulas do not take into account negative pressure, a more comprehensive formula or table for wind pressures should be devised. In order to secure exact results, tests should be made on models of the structure considered. It takes considerable time and expensive equipment, which was not available, to make such tests. It was therefore necessary to base assumptions on experiments that have been performed. Smith[3] made

[3]"Wind Loads on Buildings," Journal of the Western Society of Engineers, Vol. XIX (1914) pp. 371-392.

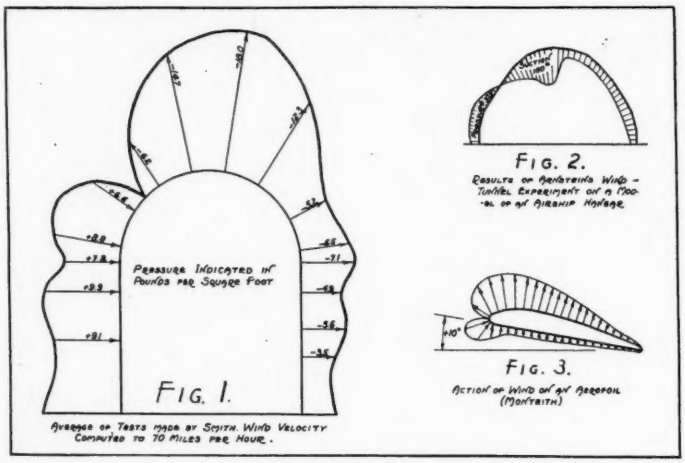


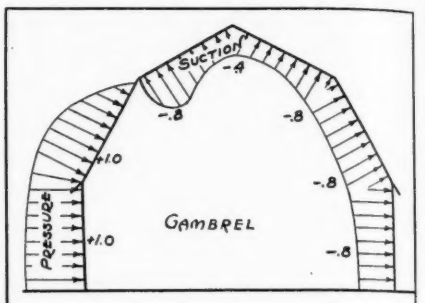
FIG. 1.

FIG. 2.

Results of Obtaining Wind-Tunnel Experiments on a Model of an Airship Hangar

FIG. 3.

Action of Wind on an Aerofoil (Montgomerith)



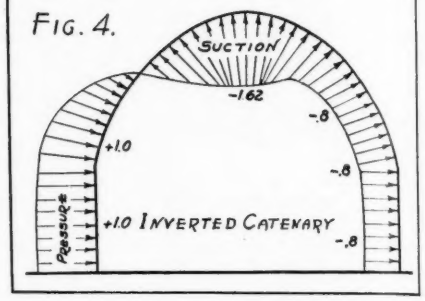


FIG. 4.

Figs. 1, 2 and 3. Wind pressure diagrams (wind from left). Fig. 4. Coefficients indicating wind-pressure distribution on two types of barn roofs, with wind from left

extensive wind tests on a rectangular model having a semi-circular roof, the model conforming somewhat to the Gothic type of barn design. The results obtained in these tests (Fig. 1.) will be used in the assumptions of wind loads, the wind velocity having been computed to 70 miles per hour. The accuracy of the tests is verified by a study of wind pressures on a hanger model made by Arnstein, and reported by Watson[4], shown in Fig. 2. Fig. 3 shows a wind-pressure diagram of a model airfoil, which confirms somewhat the results derived by Smith.

In deriving pressures for various wind velocities at various places on the model, the value of P (pounds pressure per square foot) would vary as V^2 (the square of the wind velocity in miles per hour). Fig. 1 shows the pressure in pounds per square foot for a 70-mile wind. The maximum pressure for a wind of this velocity on a structure with a semi-circular roof would be —18 pounds per square foot at the point illustrated.

As further evidence that suction pressure is the greater, Dryden and Hill's report on "Wind Pressure on Circular Cylinders and Chimneys[5]" states that the positive pressure is effective over only a small area of the cylinders, while the negative pressure exists over the large remaining area and is of greatest intensity where the wind passes around the cylinder, due to increase in velocity parallel to the surface. There is also a negative pressure on the leeward side caused by the rarefaction of the air, but it is much smaller.

Further analyzing the results of the tests by Smith, there are various explanations that should be made. The fact that there is suction on the windward side of the roof is due to the increase in velocity of the air over that section, thus decreasing the pressure. Aerodynamic experiments show that there is a lifting pressure on airfoils (Fig. 3) and this principle might be applied in this instance. Rathbun[6] states that the lift is 60 to 80 per cent of the total force acting. In aerodynamics it is conventional to express pressure differences as ratios or coefficients of the velocity-pressure, and this has been done in this study. This is accomplished by using the formula $P = KAV^2C$ where P is the pressure in pounds per square foot, K is a constant (0.00256), A is the area in square feet, V is the velocity in miles per hour, and C is a coefficient, the values of which are shown on the diagrams.

[4] "Erecting the World's Largest Roof," Civil Engineering, Vol. I (1930) pp. 71-72.

[5] "Wind Pressures on Circular Cylinders and Chimneys," U. S. Department of Commerce, Journal of Research, Vol. V (1930) pp. 653-693.

[6] "Aeroplane Construction and Operation," pp. 70-122.

Fig. 4 shows the distribution of wind stresses on farm buildings by means of the coefficient system based on Smith's tests and suggestions by Dryden. Two types of barns were here considered, one having a gambrel roof and the other an inverted catenary roof. In the case of the inverted catenary the coefficients are similar to those found in Smith's tests as the general designs of the roofs are comparable. In applying the coefficients computed from Smith's diagram to the gambrel roof they were found to be too high and were reduced according to the recommendation of Dryden.

The conclusions drawn from this study are:

1. Present formulas do not consider suction or lifting forces.
2. The tests by Smith may be used as a basis for wind load assumptions as other results confirm his experiment.
3. Decreased static pressure, or suction, acts over the greater portion of the exposed area of the building.
4. There is much necessary experimental work to be done to determine the effect of wind action in order that more intelligent designs can be made.

TESTS ON PLATE JOINTS

Comparative tests were made on gambrel roof barn plate joint models representing four types of construction.

Barn roof dimensions as a basis on which to scale the models were calculated from average-weight dairy cow floor space requirements, hay requirements, and loose hay storage space requirements. Based on an average weight per cow of 1200 pounds, to be fed a maximum of 1½ pounds of hay per day per 100 pounds weight, over a feeding period of 240 days per year, the hay weighing 4 pounds per cubic foot, stable area being 80 square feet per cow, the barn width being 34 feet, and allowing for waste mow space, it was determined that to provide sufficient mow space above the stable, the cross-sectional area of the mow should be about 500 square feet. An endeavor was made first to design the roof so that the rafters would extend down to the mow floor. Plans were drawn and in the design regular length members (16, 14, and 12 feet) were employed. After trying the members in the various possible arrangements it was found that insufficient area could be provided by this method. Therefore, the studs were extended 3 feet above the mow floor and the roof formed

with 14-foot lower and 12-foot upper members. The ridge was then 21 feet, 6 inches above the mow floor.

A 4-inch scale was employed in constructing the models to be tested. It was chosen as the largest that could be fabricated in the space afforded in the laboratory. Fir finish, a fine-grained, knotless lumber, cut to one-third the size of the original 2x6-inch, 1x8-inch, and 1x6-inch dressed lumber, was used for the members and braces. Proportional sized nails were used on the basis of the assumption that 2-inch material would be nailed with 16d and 1-inch material with 8d nails.

In these tests dead and live loads were considered. The resultant loads were used in making the tests as the reactions at the ends of the members were the same as though the loads were distributed. Snow loads were neglected because the storms causing damage occur mainly in the summer and because snow tends to increase the dead load, counteracting the lifting forces of the wind during storms.

As no wind tests had been made on a model of a barn it was necessary to use the wind loads previously derived and shown in Fig. 1. Although the distribution of these loads is only assumed, it is believed that they approximate actual conditions and can thus be used for the comparative tests which were made. Using the results of Smith's tests, the loads for various rafter members were determined at different wind velocities. The point of application of these loads was derived by the application of the principle of moments.

In the construction of the models an endeavor was made to have the nailing as uniform as possible. The plate joint in one case had no bracing and in two tests braces were added, while in the fourth method tested the plate was omitted. The rafter framings to be tested were numbered from 1 to 4, inclusive, and will be referred to by these numbers. (Fig. 5.) In Nos. 1, 2, and 3 the nailing at the plate joint was similar. No. 2 had a brace 4 feet 1 inch by 6 inches, and No. 3 had a brace 11 feet 1 inch by 6 inches.

The construction of No. 4 does not follow general construction practice. This joint was made by nailing a 2x6-inch ribbon to the stud, which had been notched, notching the rafter to fit the ribbon, and then joining the members with five 16d nails. A 2x4-inch plate was nailed to the end of the stud, which extended above the rafter. The object of this plate was to aid in holding the studs in line. It would also serve as a base for the construction of the cornice. This joint has the advantage of being easier to nail, and the nails have a greater holding power than when toe-nailed, especially as in actual construction they could be clinched.

Each of the models was tested to destruction in the same testing frame. Several duplicate tests were made on each type of joint. The results showed failures as follows:

No.	Plate failed at a load equal to a wind velocity of
1	95 miles per hour
2	125 miles per hour
3	120 miles per hour
4	150 miles per hour (actual velocity to cause failure was not determined)

CONCLUSIONS

1. The plate joint, when improperly braced, results in a large portion of building losses due to the wind.
2. Under average methods of bracing the plate joint, the failure occurred at the purlin.
3. The deflections were about the same under smaller loads. It was not until some portion loosened that there is a marked change in the trend of the curves.
4. There is no advantage of using a long brace as compared to a short brace at the plate.
5. The nailing of the rafter to the side of the stud resulted in by far the greatest strength, and this method of construction seemed simpler.

It is evident that there is a great need for informing the farmer and farm contractor on proper construction methods. This will be a somewhat difficult task as structures men are also basing their designs on a "factor of ignorance," which can only be overcome by a great amount of intelligent research. The problem of wind loads is one which challenges the structural agricultural engineer.

Effect of Machine Method on Stand of Cotton

By Deane G. Carter[1] and E. B. Whitaker[2]

PRODUCTION with large machines and large power units has no adverse effect on stands of cotton, as evidenced by one year's study made by the Arkansas Agricultural Experiment Station at the Cotton Branch Station.

The 1931 season was favorable, as the growing season was long, rainfall adequate, no boll weevil damage occurred, and a full stand of cotton was established. In the cotton machinery studies conducted, the equipment used on various blocks included a mechanical chopper, smoothing harrow, rotary hoe, check-row planter, and one-half row, one-row, two-row and four-row cultivators. If any serious damage due to machines occurred to the crop between the time the desired stand was established and the time of harvest, there would be evidence from observations, yield, and actual plant count or stand losses.

The assistant director in charge reported "Field observations showed that there were no ill effects, and a stand of cotton was maintained that allowed a maximum production of cotton over all areas."

There was no correlation between yield, machine method, or stand. The variation between 1028 and 1280 pounds of seed cotton per acre was apparently due to differences in soil condition.

Plant counts give the most accurate measure of effect on stand. Counts were made by a sampling method in which exact counts were made on 50-foot row lengths, selected at random in each plot. The first count was made when the plants were 6 inches high and the desired stand was established. Just prior to harvest the same sample areas were again counted. The losses in number of plants and in per cent of original stand are shown in the accompanying table. Three of the four losses amounting to 10 per cent or more occurred on plots having the highest number of plants per acre originally, indicating soil condition or competition between plants as the principal factor.

There were no significant differences in stand loss, indicating that four-mule and tractor power, and large capacity machines, do not cause a loss in stand.

Effect of Machine Method on Stand of Cotton

Block	Cultivation Method	Original stand (plants per acre)	Losses (plants per acre)	Per cent of original stand lost
A	½-row	43,195	4371	10.0
B	1-row	34,915	2040	6.0
C	2-row	34,915	2693	7.7
D	4-row tractor	39,283	4479	11.4
E	½-row and rotary hoe	30,074	1103	3.8
F	1-row and rotary hoe	31,280	3153	10.0
G	2-row and rotary hoe	26,765	1749	6.5
H	4-row tractor and rotary hoe	28,949	2544	8.8
I	1 and 2-row and mechanical chopper	51,296	5528	10.8
J	1 and 2-row and smoothing harrow	29,715	614	2.0
K	1 and 2-row and cross cultivation	20,754	750	3.6

[1]Professor of agricultural engineering, University of Arkansas. Mem. A.S.A.E.

[2]Assistant director, Arkansas Cotton Branch Equipment Station.

Sugar Beet Machinery Development[1]

By E. M. Mervine[2]

MUCH progress has been made in the development of sugar beet machinery during the past year. Labor requirements for one of the most arduous tasks, that of blocking and thinning, may be cut by approximately 40 per cent. The mechanical harvester has demonstrated its ability to take the place of many hand laborers and to do work of an equal or superior quality.

Contract labor at present represents by far the largest portion of the labor involved in raising beets. The cost of contract labor represents the greatest single item in the cash outlay of the farmer. Contract labor is frequently imported and occasions large transportation costs as well as difficulty of assimilation in the community.

A measure of the growth of mechanical blocking, as a substitute for the contract labor in the Minnesota-Iowa territory, is given by Mr. C. T. Lund of the American Beet Sugar Company. Here in 1929 only five acres were cross-blocked, in 1930 between 10 and 12 per cent of the entire acreage, and this year (1931) between 25 and 30 per cent were cross-blocked. He states that about 40 per cent of the total acreage was worked by white labor in 1931, an increase of more than 200 per cent over that used in 1930.

Mechanical blocking in its simplest form is merely the pulling of the ordinary beet cultivator across the field at right angles to the rows. For use in this discussion the original stand of beets is defined as being the percentage of inches of row in which beet seedlings are found. This percentage is determined directly by observing the number of inches, on a 100-inch scale placed along the row, opposite which there are one or more beet seedlings. Gaps in the original stand are so much in evidence that their importance is correspondingly magnified. The final stand is usually observed to be much better than expected.

A simple mathematical calculation, based on probability and chance, coupled with an experimentally determined correction factor, shows how to set the cross-blocking cultivator shovels to give the desired stand of beets. Let

a = number of inches in 100 inches in which there are beets, that is, the original stand of beets

m = number of inches left by blocker (size of block)

n = number of inches from center to center of blocks

N = number of beets in 100 feet of row after blocking

The probability of there being beets in a given inch of row is $(a \div 100)$. The probability of there not being beets in a given inch of row is $(100 - a) \div 100$. The probability of there being beets in m inches of row is $1 - [(100 + a) \div 100]\, m$.

Then $$N = \left[1 - \left(\frac{100 - a}{100}\right) m\right] \frac{1200}{n}$$

Results obtained from this equation are based on an equal mathematical probability of beets being either bunched or being uniformly distributed. Due to the beet seed having several germs per seed ball, there is greater probability of the seedlings being bunched than of their being equally distributed. This variance is measured by experimental data and is compensated for in the formula by subtracting 3.6 from the derived value of N. Moreover, the number of beets left in the field by the thinners is, on the average, only 95 per cent of the number of plants left by the mechanical blocker. Hence, the number of expected plants left after mechanical blocking and hand thinning is

$$N = \frac{95}{100}\left[1 - \left(\frac{100 - a}{100}\right) m\right] \frac{1200}{n} - 3.6$$

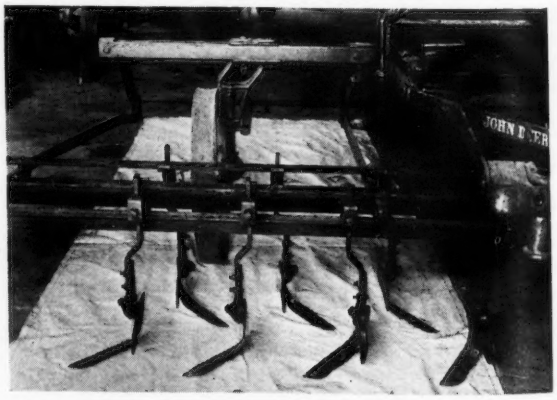
The accompanying curves are based on the above formula. The 4-6 combination means that a 4-inch block is left and 6 inches are cut out by the shovels. To illustrate further, if the germination stand is such that 45 per cent of the inches in the row contain beet seedlings, then with the 4-6 combination of shovels it would be expected that the stand of beets after thinning would be 99 beets per 100 feet of row.

The results obtained this year in the cross-blocking work have been gratifying. From the engineer's point of view it has been interesting to be able to make a mechanical set-up, based on mathematical calculations, that would give desired results. From the agronomist's point of view it has been equally gratifying to have the crops yield in response to the mechanical regularity of the machine work. Apparently mechanical blocking is less abusive to the small seedlings and that, together with the cultivation that the ground gets during this operation when the weeds are most easily killed, makes it an easy method to get the farmer to adopt.

It will be noticed from the curves that almost any desired result could be obtained. In general the opinion is expressed that the stand should be 100 beets per 100 feet of row. Some growers attempt to get this and fail because of careless laborers. Others believe that their soil is not rich enough to raise that many beets. Still others believe that in their fields they will obtain a greater tonnage by giving the beets a greater spacing and less competition. Many of the sugar companies buy the beets not only on the tonnage basis but also on the sugar content. Therefore, the farmer is interested in raising the maximum weight of sugar per acre, in which sugar percentage, as well as tonnage, is a factor.

When the beets are received by the sugar company they are sampled for average weight of beet. Since they determine the acreage and tonnage per farm, they can calculate the stand that each farmer had. This has shown an average, for Colorado, of less than 70 beets per 100 feet of row.

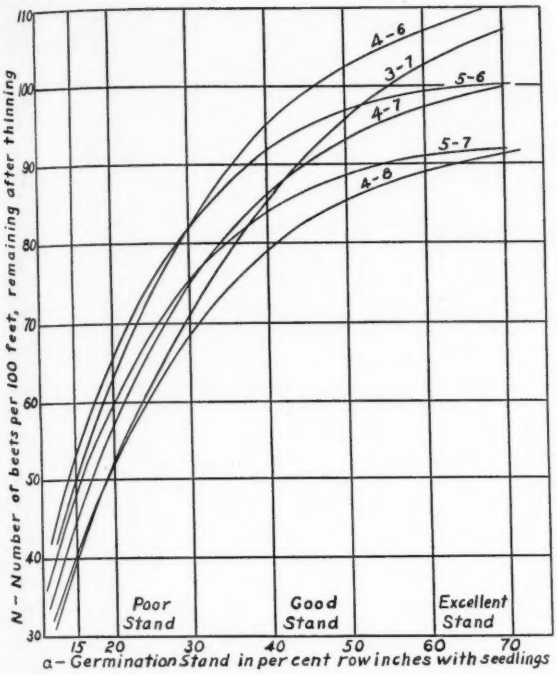
There is then a happy medium which the farmer should approach in spacing his beets. If he finds that that spacing should be 100 beets per 100 feet of row and he has a good stand, such as 45 per cent, he will have to set the shovels



A beet cultivator equipped with sweeps set for blocking. Shovels may also be used. The staggered arrangement leaves the ground level and prevents clogging with trash

[1]Paper presented at the Power and Machinery Division session of the American Society of Agricultural Engineers at Chicago, December 1931.

[2]Agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. A.S.A.E.



The relationship between original stand, size and spacing of blocks, and number of beets per hundred feet remaining after thinning

on his cross-blocking beet cultivator so that they will cut out only 6 inches of row, leaving a block of 4 inches. This would mean that most of the beets were only 10 inches apart. If he has an excellent stand of beets to start with and wants to leave 100 beets per 100 feet of row he can set the shovels to leave beets every 11 inches, either by cutting out 7 and leaving 4, or by cutting out 6 and leaving 5 inches.

Frequently the result is considered satisfactory if the final stand of beets is 90, which result can readily be obtained by cutting out 8 and leaving 4 inches of row, or by cutting out 6 inches and leaving 5.

It has always been considered desirable when cultivating beets that the soil should not be pulled away from the small plants. This is equally true of cross-blocking. The mechanical blocking of beets is apparently superior to hand blocking in that the laborer with his hoe pulls soil from the row to the extent that the small beet seedling, which is thinned at the same time, stands up on a little mound of soil, with a portion of its root exposed to the sun, and high enough that, apparently, the soil is dried out more rapidly than is desirable. The mechanical blocker may be equipped with almost level sweeps so that the soil may be left practically level. It is then practical, and apparently desirable, that the remaining block of beets be allowed to stand for several days before thinning in order that the more hardy plant may have a chance to assert itself. The statement is made that the strong beet at thinning time is the big beet at harvest.

Conditions, as met in different localities, may require different blocker equipment. A certain soil may be loose and in such a condition the ordinary sweep would push it ahead, tearing the small beet seedlings from their ground. A combination of disk and shovel equipment may meet this condition as well as it would a trashy soil. In order to prevent pulling the soil from the beet row, it may be desirable to have the shovel or sweep throw soil toward the plants and use shields to prevent the plants being covered.

In general, farmers may properly equip for cross blocking with little additional outlay for new tools.

HARVESTING MACHINERY

The present hand method of harvesting beets requires first that the farmer with a team or tractor go through the field and pull the beets. Some years this is a two-horse load; in 1931 the ground was so hard in Colorado that it was a three or four-horse load. In California it is a tractor load. There two rows are pulled at once, but generally the ground is so much harder than in the mountain states and east that the load is more than twice that for one row.

The remaining harvesting processes are all hand operations. In some cases the beets must be bumped together in order to knock off loose adhering dirt; they must be topped and thrown in piles or windrows, and eventually loaded into truck or wagons. This loading is done either with beet forks or the individual beets are thrown in by hand.

The laborer receives approximately $9 per acre for these operations. He may harvest ⅓ acre per day, more or less. The usual procedure is for the truck driver to pull up alongside a pile of approximately 250 pounds of beets, and scoop them into the truck, then move to the next pile, until he is loaded. He may load at the rate of a ton in 7 minutes, or if he is slow, it will take him three times that long. Truckers haul about 10 loads per day, and are paid by the ton-mile for the hauling. Some soils permit the use of heavy trucks hauling as much as 6 tons per load. Others permit less than 2 tons. Much hauling is with 2½-ton loads.

For many years the work on harvesting machines has been largely concentrated on the system whereby the beet is topped while it remains in the ground. It was considered the most logical system in the belief that, while the beet is held upright firmly in the ground, it could be more satisfactorily topped than when removed from the ground. It was believed that if topping could be accomplished, then the lifting would be easy. Satisfactory topping can be done in the ground, but to date we have not been able to mechanically separate the beets from the dirt.

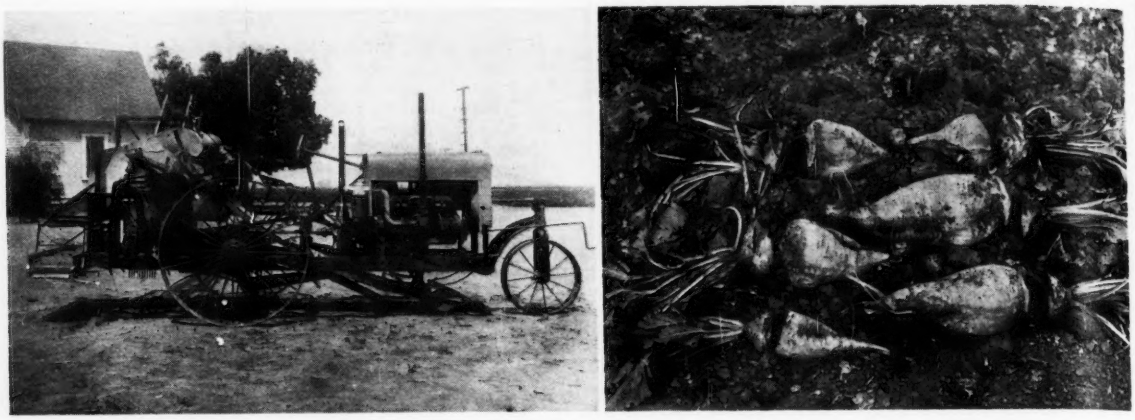
Ordinary separating screens are not sufficiently effective in separating dirt from the beets. Too frequently the clods are so hard that agitation, which would be hard enough to break them, would be hard enough to hurt the beets also.

The plan of incorporating a man in the operation at this point, either on the machine or following the machine, has not been effective. On the machine the clods have been too numerous for him to handle, and off the machine it has required an excessive number of men.

More encouraging are possibilities of lifting the beet without lifting an excessive amount of soil with it, by use of a prod, fingers which grasp the beet on its sides, or by lifting in an ordinary manner, but, as soon as it is lifted, placing it in between two conveyors. The conveyors hold the beet practically vertical, and at the same time give it a slight rotation, cleaning it of dirt. The conveyors are operated on shafts, which incline out and forward from the vertical. The conveyors are closer together at the bottom than they are at the top, their angle being about the same as the taper of a normal beet. The shafts, being inclined forward, permit the beet to be admitted close to the ground, and, as it travels backward, given elevation. Loose dirt or crushed clods that may have entered with the beet are free to drop out below and between the conveyors.

During the past year much work has been done on a harvester which first pulls the beet, using its top to pull it vertically out of the ground. This lifting is accomplished at the same time that a lifting plow loosens the beet in the ground. The beet is then elevated into a mechanical topper. In this device the beet top is grasped consecutively between the corresponding members of two sets of six roller bars which move in an elliptical path. These bars continually grasp and regrasp the top nearer the crown of the beet, holding it firmly, gaging the point at which it is to be topped, and at the same time moving it rearward into a set of topping knives.

The action of the roller bars gage the top or crown



(Left) A single-row, self-propelled one-man beet "combine" which loosens the beet, lifts it by its top, elevates, and tops it, and deposits the beets in a truck and the tops in piles. (Right) Beets and tops, showing the work of Mechanical topper

of the beet slightly to the sides rather than directly on top. This makes a difference in the amount of top severed as compared to the amount severed by the topper that works in the ground. When gaged by rolling over the ground a large top will raise the finder wheel higher than would a small top. This is not the case with the roller bars since they gage on the sides of the stalks at the top of the crown.

By the complete action of the harvester with one operator the beets are lifted, elevated, topped, run over screens, the beets elevated to the truck, and the tops placed in piles or windrows as desired. Up to the present time this is a one-row machine and for that reason lacks capacity. There is no reason, as far as the mechanical principles of the machine are concerned, why it should not be built into a two-row machine. Such a machine would have a speed of delivery that would load a truck in 15 minutes, or even less, when the tonnage of the beets was high.

The machine might also be equipped with a hopper instead of the present elevator. Then it could be operated day and night as a single-row machine, with a day and night capacity of over 7 acres, enough to pay a return on the investment. The harvester would have the beets piled in larger piles than is now customary, making the loading and hauling more simple than it now is.

From the standpoint of quality of work this method of harvesting can be pronounced a success. The beets are topped in a way that enables the farmer to deliver the maximum tonnage to the factory without an undue amount of tare. The mechanical features of this harvester are such that any desired type of topping could be obtained. If the sugar company should require a straight cut, that could be given as well as a tapered cut. With every other beet harvester there has been some fundamental difficulty that has seemed insurmountable, but with this machine there does not seem to be any fundamental objection.

The experimental machine this year has performed on a scale that might be considered as commercial. There is still a question as to what would happen if the tops were frozen. This year (1931) has been an ideal year as far as weather has been concerned; 90 per cent of the crop in Colorado had been harvested by November 1. There had been nights when the temperature had been down below 20 degrees (Fahrenheit). The tops are not seriously affected by these temperatures, so it is possible that in most years you could depend on the tops standing up. There are years though, when the freeze comes early and the tops may be frozen down level with the ground. The lifting gathering points are shaped somewhat like the gathering points of a corn picker and would be effective in gathering many down tops but it is possible that the number of beets missed might be too great.

There are numerous machines, attachments to machines, or improved methods yet to be devised to make the mechanical growing and harvesting of beets a complete success, but what was supposed to be almost impossible, namely the mechanical harvesting of beets, is now "just around the corner."

The Agricultural Crisis[1]

A POST-WAR deflation has always borne most quickly and most heavily on agriculture. But in the United States, agriculture is now burdened with new ills, particularly with regard to the great staples of wheat and cotton.

Wheat is not only feeling the impact of the expansion of new territories, in Canada and Russia, but also that of new varieties and processes. The new processes, largely mechanical, result in a great increase in both acreage and production per acre. They also make possible a satisfactory extension of the industry into more arid regions than had before been thought possible. Modern methods are also penetrating areas like Russia.

The same extension of areas applies to cotton raising. In foreign countries there are the new plantings in Egypt, the Sudan and Turkestan; and in the United States the new cotton fields of northwestern Texas, where climatic and other conditions have led to new and more economical methods of production. This increase in production has met a decrease in demand due to the introduction of rayon and changes of fashion in women's apparel.

This is commonplace process, but nonetheless distressful. It is one the elements responsible for the present economic situation in this country.

* * * * * *

The condition of agriculture does not lend itself so readily to practical recommendations as do some of the other elements of the general economic problem that have been considered. Certain of the lines of action suggested would, however, have an immediate and useful effect on the situation. This is especially true of the control of the price level. To no other group would a stabilization of money be more helpful. The conditions of agriculture are such that it has no inherent self-protection. As already stated, the inflation of that industry was urged and aided by the government, for purposes connected with the carrying on of the World War. The deflation hit the farmers in full force long before it was felt by other industries.

[1]From a progress report of the American Engineering Council Committee on the Relation of Consumption, Production, and Distribution.

The Cost of Drainage Pumping[1]

By John G. Sutton[2]

THERE are at the present time about 450,000 acres of river bottom land reclaimed by pumping in some 63 organized drainage districts in the Upper Mississippi Valley. Of this total, 170,000 acres lie along the Illinois River and about 280,000 acres along the Mississippi River between Savanna, Illinos, and St. Louis, Missouri. These bottom lands are so low in relation to existing river stages that the run-off from most districts must be removed by drainage pumps. A few, mostly along the Mississippi, obtain gravity drainage at low river stages.

At the end of 1930 the pumping plants of these districts contained a total of 25,501 rated horsepower, of which electric motors amounted to 45 per cent; steam engines, 33 per cent; and oil engines, 22 per cent of the total. Engineers of the U.S.D.A. Bureau of Agricultural Engineering have investigated for several years, the cost of operating typical pumping plants to determine the costs of pumping and whether such costs could be reduced; to compare the costs of pumping with steam, electric and Diesel power; and to determine the most economical design of drainage pumping plants. Six annual progress reports have been issued to enable drainage officials to compare their annual pumping costs and determine what economies could be effected. The final report covering this investigation is now being prepared for publication.

The cost of drainage pumping is of widespread public interest at the present time in the states bordering the Upper Mississippi River. The Mississippi River Commission is commencing the construction of a 9-foot channel between St. Louis and St. Paul and several dams are planned which will raise low water stages of the Mississippi; cause increased amounts of pumping in some districts; and entirely shut off the gravity flow of other districts. Districts thus affected have recently organized the Mississippi Valley Drainage Association for the purpose of obtaining compensation for damages that will be caused by these raised river stages. The object of this paper is to discuss the costs of operation of drainage pumping plants and show the relation to each other of some factors affecting such operating costs.

Drainage pumping is quite expensive even with the most efficient equipment, the cost usually ranging from $1.00 to $3.00 per acre per year in districts studied—the weighted average cost being $1.90 per acre per year. Pumping costs will usually range from 20 to 50 per cent and average probably 30 per cent of the total drainage costs.

The investigation conducted by the Bureau of Agricultural Engineering has determined that in many instances the operating efficiency of a drainage pumping plant can be improved in one or more of the following ways: (1) By having a competent engineer supervise the plant's operation; (2) by properly regulating the speed of the pumps; (3) by operating the most efficient units as much as possible; (4) by adjusting, cleaning, or repairing pumping equipment; or (5) by installing more efficient equipment. In some instances a lower and more constant water level in the suction bay would provide better drainage for the district.

METHOD OF COMPUTING EXPENSE

In determining the annual cost of pumping it is necessary to take into account the annual operating expenses, and also interest and depreciation on the plant. These last two items, known as fixed charges, are apt to receive little consideration although they frequently amount to more than one-half of the total cost of pumping.

To compute depreciation accurately three factors must be known: The first cost of the plant, its life, and its salvage value. Of these items the first cost is the only one that can be determined with accuracy. The salvage-value factor is so small that it can be neglected for practical purposes.

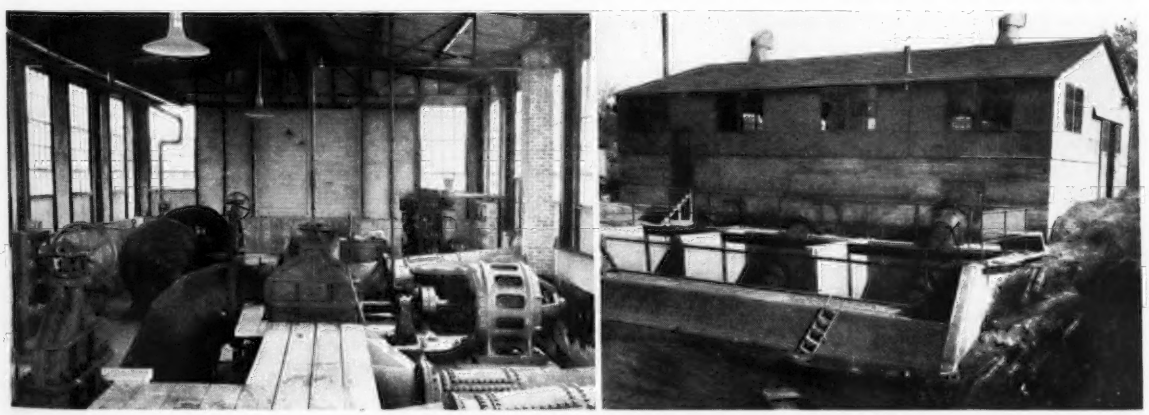
The annual depreciation charge has been taken as an amount which, if collected annually and invested at 4 per cent interest, would equal the original cost of the equipment at the end of its estimated life. Interest on the original cost has been computed at 6 per cent for all plants, although actual interest rates on money received from most bond sales have usually exceeded this figure.

Using these assumptions as a basis it has been found that the annual fixed charges total about 8 per cent of the first cost for electric plants; about 9 per cent for steam plants, and from 8.5 to 9.5 per cent for oil-engine plants.

In comparing the fixed charges of various pumping plants it is necessary to consider the date of construction since construction costs have varied greatly during the last 18 years. Frequently quicksand was encountered in

[1]A paper presented at a meeting of the Land Reclamation Division of the American Society of Agricultural Engineers at Chicago, December 1931.

[2]Assistant drainage engineer, U.S.D.A. Bureau of Agricultural Engineering. Jun. Mem. A.S.A.E.



(Left) Interior of the Lima Lake drainage district pumping plant. In the background is a 36-inch, bottom-suction centrifugal pump driven by two 250-horsepower synchronous motors mounted on the same shaft. In the foreground is a 36-inch, mixed-flow, screw-impeller pump direct connected to a 250-horsepower induction motor. (Right) The new Havana plant, which drains the Lacy, Langellier, and West Mantanzas districts

foundation work, or flood conditions along the river increased the cost much above that originally estimated. Any factor that influences the first cost must be considered because the fixed charges depend to a large degree on the money actually spent on the plant.

TYPICAL DISTRICTS STUDIED

The operation of pumping plants of 16 representative drainage districts has been studied. The districts ranged in size from 4,009 acres to 23,591 acres. The run-off capacity of the plants studied varied considerably, ranging from 0.15 inch to 0.55 inch per 24 hours from the watershed area. Consequently the effectiveness of the drainage varied greatly.

Data obtained by this investigation show little difference in the average cost of pumping with oil-engine, electric and the most efficient steam plants. However, the minimum costs were obtained on a simply constructed semi-Diesel plant. On the other hand, electric plants are more convenient and can be run by a less skilled operator. No new steam plants have been built since 1920. Many of the earlier steam plants have been abandoned, due to the high cost of coal and labor, and sometimes due to poor mechanical condition of the plant. Some of these districts have installed electric motors to drive their old pumps; others have added new units and used the old steam plant only for stand-by service.

In recent years the rates available for electric power have been largely instrumental in determining whether oil engines or electric motors would be installed. During the period from 1921 to 1926 electric rates were so high that only 650 horsepower of new electric motors were installed in the Upper Mississippi River plants as compared with 2,938 horsepower of oil engines. Several reductions were made in the power rates so that by 1927 the total operating costs of electric plants were comparable to those for oil-engine plants. During the period from 1927 to 1930 a total of 4,683 horsepower in electric motors was installed, compared with 2,085 horsepower in oil engines.

Electric power averaged 58 per cent of the total cost for the electric plants. This suggests that special consideration should be given any refinement that might improve the operating efficiency of an electric plant. Most plants studied have obtained "off-peak" pumping discounts at least part of the time. The Green Bay and the Indian Grave plants have obtained very favorable rates for power; the Green Bay rate averaged 1.08 cents per kilowatt-hour and the Indian Grave rate, 1.28 cents. Power rates for the remaining districts studied averaged approximately 2 cents per kilowatt-hour during the last 15 years. Fixed charges on the electric plants averaged 29 per cent of the total cost and labor amounted to only 7 per cent of the total. Other items of cost were smaller in amount.

Coal was the largest item in the cost of operation of the steam plants, averaging 42 per cent of the total. Fixed charges, averaging 21 per cent of the total, were less than on the electric plants. However, this was due to the fact that the steam plants were constructed prior to 1916, during a period of lower prices. Labor averaged 17 per cent of the total for steam plants, and supplies and repairs, 11 per cent.

Fixed charges of interest and depreciation constitute the largest item in the expense of oil-engine plants, averaging 43 per cent of the total costs. Therefore, it is especially desirable that good care be taken of oil engines to increase their life and dependability. The fuel oil for this class of plants amounted to only 17 per cent of the total costs. Labor was greater than for electric plants, averaging 16 per cent of the total, and supplies and repairs averaged 13 per cent.

FACTORS THAT AFFECT COSTS

Quantity of water to be pumped is one of the most important factors affecting pumping cost. The South Beardstown district had the greatest run-off of any plant studied, amounting to 43.61 inches per year during the five-year period from 1925 to 1929, which was 7 per cent greater than the average rainfall. The Henderson County is another plant that pumps a large amount of water, averaging about 33 inches per year during the last five-year period. These plants have to pump nearly every day in order to keep the water down in the suction bay.

The average amount of water pumped by plants in this territory will usually range from 15 to 25 inches per year as eleven out of the sixteen plants which were studied pumped an average run-off within this range. During dry months when the river is at a low stage these plants operate very infrequently, possibly once a week or during very dry weather, possible twice a month. However, when the river is at a high stage after heavy rainfall the run-off is practically as great as from a district such as the South Beardstown or Henderson County.

A few of the districts obtain gravity drainage a large part of the time and operate their pumping plants only when the river is above flood stage. For instance, the Fabius plant pumped an average run-off of only 10.24 inches during the four-year period from 1925 to 1928, and the amount it pumped during 1930 and 1931 was negligible. The Mauvaisterre pumped an average of 7.43 inches during the three-year period from 1927 to 1929.

As previously mentioned there is keen interest at the present time in districts along the Mississippi in determining the effect that backwater from dams will have on the cost of pumping. The dam at Keokuk raises the low water stage of the Mississippi approximately 10 feet at the Green Bay district and 6 feet at the Henderson County district. In 1925, which was a dry year, the Green Bay plant pumped 21.65 inches of run-off compared with 10.82 inches for the Bay Island plant and 7.07 inches for the Indian Grave plant. Neither the Bay Island nor the Indian Grave plants are affected by backwater. In 1928, an average year, the Henderson County plant pumped 32.84 inches compared with 18.53 inches for the Bay Island and 15.88 inches for the Indian Grave plant. These data that have been obtained on the Green Bay and Henderson County plants indicate that a material increase of from 50 to 100 per cent in the amount of pumping may occur when a district is affected by backwater from a dam.

The lift pumped against has an important effect on the cost of pumping but not as much as many assume. It has been found that, as generally operated, pumping plants equipped with centrifugal pumps require approximately 70 per cent as much power to pump out a given quantity of water at a 10-foot lift as would be required at a 20-foot lift. The power required to pump drainage water does not decrease in direct proportion as the static lift decreases, because the pump efficiency also decreases rapidly and the losses in the pipes become larger at the low lifts. Furthermore, the cost factors other than power used are not affected greatly by a change in lift.

In several of the districts it has been possible to effect a saving of 15 to 25 per cent of the power used by proper regulation of the speed of the pumps.

The efficiency of pumping units is of course a primary factor affecting the cost of pumping. Some screw pumps have given better than 70 per cent efficiency at all heads between 7 and 24 feet with one change of speed, and a maximum efficiency of 80 per cent. This is a very desirable type of pump for a drainage plant because it operates so efficiently at variable heads.

In conclusion I wish to emphasize the point that the engineer is interested not only in economy of operation but in the effectiveness of the drainage rendered the district. To be most effective the plant must have adequate capacity. Experience has shown that a run-off coefficient of ⅜ inch per 24 hours from the watershed area for average Mississippi River districts and ½ inch per 24 hours for Illinois River districts should be used in designing most plants. Furthermore, the ditch system must be designed to conduct water to the plant rapidly, and be properly maintained. If this is not done, a large plant may be only slightly more effective than a smaller one.

Measurement of Spectral Energy Distribution for Agricultural Research

By Harry Miller[1]

IN ORDER to investigate intelligently the effects of light in plant and animal production it is necessary to measure not only the intensity, but the type as well. The wavelength determines the type of light.

Wave lengths are usually specified in Angstrom units. The Angstrom unit is equal to 0.00000001 centimeters. The classification of types of radiations and the wavelengths they embrace is, expressed in Angstrom units, as follows:

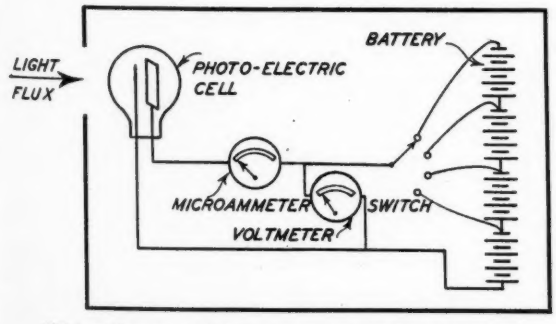
Ultra-violet	136	to	4,000
Violet	4,000	to	4,500
Blue	4,500	to	4,900
Green	4.900	to	5,500
Yellow	5,500	to	5,900
Orange	5,900	to	6,300
Red	6,300	to	7,800
Infra-red	7,800	to	120,000

Shorter than the ultra-violet are X-rays, and longer than the infra-red are radio waves. The range of wavelengths in which we are interested at the present time extends from about 2,500 to 14,000 Angstrom units. From 2,500 to 2,700 Angstrom units the rays are highly germicidal. Under favorable conditions, sun radiation down to 2,900 Angstrom units will reach the earth. The rays which have a tanning effect and prevent rickets are found between 2,900 and 3,100 Angstrom units. Just what biological effects other portions of the spectrum have remains to be determined. In order to make these determinations we must have a means of detecting the type of light under test.

A satisfactory apparatus can be built to measure both the intensity and the type of light at a very reasonable cost. The apparatus used by the department of agricultural engineering at the University of Idaho includes a photoelectric cell, microammeter, voltmeter, bank of four radio "B" batteries, and six selective filters, wired as shown in the accompanying drawing.

A photoelectric cell for laboratory purposes is equipped with a radio tube base to fit a standard radio tube socket. It resembles a radio tube in appearance. However, only two of the prongs in the base are used. One of these is connected to a coating on the inner wall of the bulb. This coating is sensitive to light. Different materials have special sensitivities for specific wavelengths. In the selection of a cell this coating should be sensitive to the wavelengths to be studied. If the range of wavelengths to be studied is long, two or more cells of different coatings are desirable.

[1]Department of agricultural engineering, University of Idaho. Assoc. Mem. A.S.A.E.



Wiring diagram of laboratory equipment for measuring spectral energy distribution

The second prong is connected to an electrode which extends up into the center of the bulb. A portion of the wall of the bulb is not coated with sensitive material in order to permit the light to enter. The light falling upon the sensitive material will liberate electrons, and the potential from the battery will sweep them across to the electrode. This process is continuous and the microammeter will register a current proportional to the intensity of radiant energy entering the cell. The magnitude of this current can be amplified by increasing the potential between the sensitive material and the electrode. In case the intensity of the light is so great as to cause a current to flow which will exceed the capacity of the microammeter, the potential may be decreased and the results brought to the basis decided upon from previous calibrations. Wide ranges of intensities usually are studied, and for that reason it is desirable to have a multiple switch to adjust the potential to suit the capacity of the microammeter.

For the determination of intensity of radiation in a given region the spectrum selective "filters" are placed in front of the cell. These are now obtainable transparent to very short ranges of wavelengths. For example, if it were desirable to find the amount of energy emitted in the blue region, a filter that is transparent to blue light only (that is, from 4,500 to 4,900 Angstrom units) would be placed in front of the cell. The deflection on the microammeter would then be due to radiant energy having wavelengths, from 4,500 to 4 900 Angstrom units. By using several filters of different transparencies the spectral energy distribution of a source of light can be determined readily. The radiant energy can be determined in lumens by referring to the characteristic curves furnished by the manufacturer of the cell. This curve shows the relationship between energy received and current passed for various wavelengths for different potentials applied to the cell.

The only precautions necessary in the use of filters are to keep them clean and to bear in mind that the ultraviolet filters are unstable and that their range of transmission will change with usage. However, they can be rejuvenated by subjecting them to a temperature of 250 degrees (Fahrenheit) for about an hour. If they are not used more than a total of one hour between periods of rejuvenation good results will be obtained. As a measurement does not require more than one-half minute, rejuvenation is not required very frequently. The Basic Science Research Laboratory at the University of Cincinnati has been very successful in using chemical stains on transparent materials for filters. According to reports, these can be prepared very economically. Any photoelectric cell is subject to fatigue. Consequently, the measuring should be done as quickly as possible and the entrance to the cell should be kept covered when not actually taking measurements. The cell will recover very quickly and will give accurate results.

Two type of cells are available, vacuum and gas-filled. The latter passes much larger currents due to the ionization brought about by the flight of electrons to the center electrode. The larger currents make it possible to use a less sensitive microammeter or galvanometer, which is desirable for portable apparatus. Potentials on this type of cell must not exceed 100 volts, otherwise the cell will arc when measuring high light intensities, which will result in destruction of the cell itself and the microammeter. The vacuum cell is free from such dangers, but passes a comparatively small current, which requires a much more sensitive galvanometer. Its curve showing the relationship between light intensity and current is practically linear, while in the gas-filled cell there is considerable variation. However, with the aid of the characteristic curves of the

cell, this is not a serious drawback. The gas-filled cell is probably the more satisfactory for agricultural research work.

As indicated before, no one cell is satisfactory for the entire spectral range that affects plant and animal growth. If it is desired to measure ultra-violet energy, a quartz bulb cell is necessary. Such a cell is also satisfactory for visible violet, blue, and, probably, green wave bands. Its sensitivity beyond the green probably will be too low for practical purposes. A cell with a maximum sensitivity in yellow would probably be the most satisfactory for the remainder of the spectral range.

The apparatus described above is readily portable and makes it possible to measure light intensities being studied for the effect of various parts of the spectrum on plants and animals. In order to compare the work of various investigators, it is essential that we come to some standard of measurement. Furthermore, to get the exact effect of the various parts of the spectrum, it is necessary that we have a means of detecting the presence and magnitude of the wavelengths we desire to investigate.

It may be of interest to mention some of the radiation characteristics of some of the lamps as determined by a photoelectric cell. In a carbon-arc lamp the total intensity and the spectral energy distribution vary widely with the distance between the carbons. The ultra-violet output is only 2 per cent, when the distance between the carbons is ⅛ inch, of what it is at ½ inch. Consequently, erratic results would be obtained in experimental work where this factor was not taken into consideration.

On the S-1 lamp the ultra-violet output is practically nil until the bulb comes up to temperature. This requires about 90 seconds. The output from these bulbs varies widely with usage. In case a constant intensity is desired, the radiation from the lamp can be measured at regular intervals and the distance between the lamp and the object adjusted accordingly. The above examples illustrate the necessity of measuring equipment.

Soil Erosion Control in Illinois[1]

By E. W. Lehmann[2]

FROM an engineering point of view the problem of soil erosion is a problem of surface drainage, the solution of which is dependent largely on the conservation and the control of flow of surface water. The destructiveness of the surface drainage in eroding land is dependent on quantity and rate of run-off. This is more dependent on the intensity and amount of rainfall that occurs during a short period than on the total amount of rain that falls during a month or a year. Run-off and erosion are also dependent on topography, soil, and cultural practices on the land.

In Illinois excessive rainfalls occur during the time of year when much of the land has little cover crop to protect it. This is true in early spring and late summer. While the soil may be in an ideal condition for absorption at these periods, they are also in condition to erode easily when most of the water runs off. Another factor which encourages erosion is the large percentage of cultivated crops and relatively small percentage of tillable land in crops which check the flow of water.

The soil erosion map of Illinois prepared by the department of agronomy of the college of agriculture, University of Illinois, shows graphically the areas of the state that are eroded. The best estimates indicate that more than 70 per cent of the state is affected by erosion in various degrees, a total of more than 25 million acres. Nearly 5 million acres, or 12.5 per cent of the area of the state, is classified as non-agricultural land and is subject to destructive erosion. More than 5 million acres of agricultural land, 14.3 per cent of the total area of the state, including the hill land in the southern and western parts of the state, is subjected to serious erosion. A large part of this area is not suitable for the successful production of row crops. The remaining area on which there is harmful erosion is approximately 16 million acres, or 44.6 per cent of the total area of the state, and includes high-value land, much of it located in central Illinois. This land is rolling and a large part of it is affected most by sheet washing. It is gradually reaching a condition in which gullies are forming. This condition may now be found on relatively slight slopes where soil washing was not recognized as a problem a few years ago.

As to the seriousness of erosion from the standpoint of production, Dr. R. S. Smith in charge of the University of Illinois soil survey work, estimates that the productive power of the 5 million acres of hilly agricultural land subject to serious erosion depreciates at the rate of one per cent per year. At this rate it is evident that the productive power of a large area of the state has been more than cut in half since it was put into cultivation more than 50 years ago. Much of this land has reached a stage where its value for the production of crops is questionable. This annual loss in productive power by erosion of the hilly agricultural land is equivalent to the complete destruction of 320 farms of 160 acres each.

Dr. Smith estimates further that the erosion on the high-value land, which is more than one-half of all the tilled land in the state, depreciates its productive power at an average rate of 10 per cent in 50 years, which would be a net annual loss equivalent to 200 high-value farms of 160 acres each, or a total of 520 farms destroyed each year. This amount of land at $100 per acre would be equal to more than $8,000,000 a year. The fact is that these acres are not taken out of production and the loss is even greater due to the high cost of production on land continually getting less fertile. Illinois is losing in the productive capacity of its agricultural soils the equivalent of a 160-acre farm every 17 hours. This does not indicate the loss on the 4,480,000 acres of non-agricultural land.

Relative to the amount of soil actually lost by washing Dr. Smith estimates a loss of 7 inches in 50 years, or one inch in approximately 7 years on the seriously eroded areas in Illinois. The rate of erosion on the high-value land is estimated at 7 inches in 400 years, or one inch in 57 years. Geologists[3] have estimated that the wastage should not exceed one inch in a thousand years, the approximate rate of soil production.

EARLY SOIL EROSION INVESTIGATIONS

One of the direct results of soil surveys in Illinois was to focus attention on the problem of soil washing. As early as 1906 the Illinois Agricultural Experiment Station established a soil-erosion-control experiment on a 16-acre field in Johnson County, a part of which was completely abandoned when it was purchased[4]. Some gullies were 4 to 5 feet deep, and in two places about a square rod of underlying rock was exposed.

The 16-acre field was divided into five series of plots, A, B, C, D, and E. A different system of soil reclamation and control was planned for each series. Series A had been completely abandoned when purchased and was badly gullied. The gullies were filled and the area terraced at

[1]A paper presented at a meeting of the Land Reclamation Division of the American Society of Agricultural Engineers at Chicago, December 1931.

[2]Professor of agricultural engineering, University of Illinois. Mem. A.S.A.E.

[3]Dr. C. T. Chamberlin, University of Chicago.

[4]For a complete discussion see Illinois Agricultural Experiment Station Bulletin 207.

Making the second round on a five-round terrace on ground with considerable slope

5-foot vertical intervals. Series B had a few small gullies, and was protected by embankments and two hillside ditches. Series C also had only small gullies, but was badly washed. Each spring with the exception of two years, manure was applied at the rate of 8 loads per acre to the plots in this series planted to corn. Series D, adjacent to series C and washed to about the same extent, was used as a check and farmed without special effort to save the soil. Series E was not cropped, the gullies being filled with brush and the area seeded to grass.

Limestone was applied equally to the entire area at the rate of 2 tons per acre. No other mineral food was applied. Sufficient plots were provided on each series so all the crops in a 4-year rotation of corn, cowpeas, wheat and clover could be grown each year. All residues were turned under.

Although these series of plots were not entirely uniform, they were sufficiently alike to justify using the yields as a basis for measuring the value of the different treatments. Yields on Series A, B, and C were not greatly different. For corn they were 30.6 bushels per acre. For Series D it was 14.1 bushels per acre. Wheat yielded an average of 11.1 bushels per acre on treated plots and 4.6 bushels per acre on the untreated. Of clover, 0.82 ton per acre was produced on the treated and 0.21 ton on the untreated. The terraced Series A produced 31.4 bushels of corn, 9 bushels of wheat, and 0.68 ton of hay per acre.

Relative to the increased yields, due to terracing, the following statement is made in the report of this work: "This increase in returns pays for all labor of filling gullies and building terraces and maintaining them, and leaves a fair profit on each field where washing is largely prevented and soil is conserved. Series A is in a condition to be cultivated for years to come if properly cared for, while Series D cannot be cropped profitably in its present condition."

Although the above results were obtained by terracing at a nominal labor cost, on land which was abandoned, the authors in discussing the value of terracing made the following statement in a station bulletin published in 1918: "If cover crops and organic matter are used to the best advantage, and if deep contour plowing and contour seeding are practiced, there will not be much need for terracing in this state. However, the mangum terrace, properly constructed, may in some places be used to advantage."

The emphasis was put on the value of organic matter and certain tillage and cultural practices, because it was no doubt felt that these practices could be put into effect by farmers more readily than control of surface run-off by the use of terraces. This point of view has made it difficult to gain the interest of many farm advisers and farmers who think of constructing terraces as a very difficult task. This attitude has changed during the past ten years.

I believe it is generally agreed that the mangum terrace is best adapted to fields of slight slope where sheet washing carries away vast amounts of fertility each season. The slope on a large portion of the high-value land in Illinois that is subject to sheet erosion is such that terraces may be used effectively. I do not question the value of other methods of soil erosion control, but believe the mangum terrace can be used effectively in combination with the best cropping practices on more than one-half the farms in the state. We need more facts and data on all methods of soil erosion control, especially on the value of terraces.

Beginning in 1922 terracing demonstrations were held in a number of the hilly counties. This work was then done, without exception, in the area of the state where fields were so badly eroded that they were about to be abandoned. It was only under such conditions that interest could be secured. The point of view relative to the use of terraces is changing and they are now being constructed on high-value land.

Where interest in terracing the better rolling land was formerly passive, it is now becoming active. There is considerable interest in terracing schools, on the part of farmers and farm advisers. The farm leaders are taking hold of the work and community interest is being created. Where 6 to 12 farmers attended the early demonstrations we now have 50 to 100 in attendance.

One of the early handicaps in getting terracing work started in Illinois was the lack of proper equipment. Home-made drags and worn-out road graders were often the only equipment available. The development of special terracing machinery and the active interest of the agencies interested in selling this equipment is aiding in extending the use of terraces. In a few counties the farm bureau has bought a terracing machine for the use of its members. In at least one county in the state a group of bankers bought a machine and gave it to the farm bureau. Practically every county that has 25 per cent or more of its land broken and hilly has purchased a level for use in terracing work.

The present program of soil-erosion control in Illinois has as its chief object the training of leaders to further the work in the counties. Special groups of farm advisers have come together for special instruction in building terraces and soil-saving dams. A start is being made in establishing 4-H terracing clubs, a project which has been effective in certain parts of the South.

Mangum terraces are being used to advantage in Illinois on land with a fall of from 1 to 12 feet in 100 feet. Where the fall is more than this, to get the best results from terracing, we believe it is desirable to keep the area in permanent pasture, or in hay crops.

Moisture Relationships of Soils In Situ[1]

By J. H. Neal[2]

THE WEIGHTS per cubic foot of mineral soils reported by different investigators ranged from 45 to 118 pounds. The soils reported by Harmer (7)[3] that have a weight of less than 80 pounds per cubic foot were taken from the surface foot of virgin soils. The soils reported by Beckett (3), Crowther (4), Davis and Adams (5), Israelsen (9), and King (10) with a weight between 80 and 118 pounds per cubic foot are more like the mineral soils dealt with in this study. Their moisture equivalents ranged from 6 to 28, while the pore space ranged from 31 to 54 per cent. The data do not show any distinct relationship between moisture equivalent and density, but in general the pore space increases as the density decreases. The results reported by Israelsen (9) are not in accord with those of the other authors, the values for the pore spaces being much lower.

The weight per cubic foot of Minnesota peat soils as reported by Alway (1) and by Alway and Nygard (2) ranged from 7.6 to 16.0 pounds, the weight tending to increase as the per cent of organic matter decreased.

Moisture Properties of Soils. In the case of a large number of soils, the moisture equivalent of which ranged from 4.1 to 37.6, Harding (6) compared this value with "the maximum field capacity, the normal field capacity, the usual moisture before irrigation, and the wilting of the crop. The maximum field capacity applies to soils shortly after irrigation before the moisture distribution is complete. . . . . It does not cover soil saturation. . . . . The normal field capacity would apply to soils of uniform character at from 1 to 3 days after irrigation when moisture distribution had become fairly complete. . . . ." He concluded "There is a fairly consistent relationship between the moisture equivalent and the various moisture properties of soils . . . . . The relationship of the soil-moisture properties to the moisture equivalent does not appear to be linear except in the case of the wilting of the crop."

Contraction on Drying. Hilgard stated that heavy clay soils contracted from 28 to 40 per cent on drying (8, p. 113). Tempany (11) determined the linear shrinkage of cultivated soils from different parts of the Leeward Islands. He concluded there was a relationship between the value for the internal pore space of the dry blocks and the value for the linear shrinkage. He gave a formula for computing the cubical from the linear shrinkage. The values in Table I were calculated from his data.

EXPERIMENTAL PROCEDURE

For the purpose of studying some of the moisture properties of soils in their undisturbed natural position, and their relationship to the drainage of these soils, fifteen sets of 6-inch cubes were taken at alternate 6-inch intervals to a depth of four feet. Six sets were secured at Aitkin, three at Meadowlands, three at Paynesville, and three at Waseca. All but the last, which was taken in the summer of 1929, were taken in the late summer and early fall of 1928. In the case of each of these cube samples the following determinations were made: (1) Weight per cubic foot, (2) moisture content after submergence of the cubes in water for 48 hours, (3) pore space, (4) moisture content of the cubes after draining 48 hours following submergence, (5) decrease in volume upon drying, and (6) moisture content as taken from the field. With each of these cube samples a companion sample of the immediately adjacent soil was collected for use in various laboratory determinations.

Character of the Soils. In texture the soil ranged from a silty clay loam to a very sandy loam overlaid with shallow peat.

The Aitkin soil was a shallow, well-decomposed woody peat overlying a yellowish gray to gray sand to sandy loam. Strata of yellowish gray sand of variable thickness occurred below the second foot. Such a stratum was found at the fourth foot in sets A and B, and at the third foot in sets D, E, and F. No sand was encountered in set C. The peat averaged one foot in depth on the northeast quarter of the section and 2 feet on the northwest quarter. The samples taken from the northeast quarter are referred to as Aitkin-E and those taken from the northwest quarter as Aitken-W.

The surface 6 inches of the Meadowlands soils was a light brown, silty clay loam, the second 6 inches and second and third feet a gray silty loam, containing less organic matter. Occasional clay layers were encountered in the second, third, and fourth foot, one at 3.5 feet, in all three sets.

The Paynesville soil varied from a muck 6 inches in depth to a well-decomposed peat 2 feet in depth. Set A was taken in the peat and sets B and C were taken in the

Table I

Soil	Moisture equivalent*	Organic matter	Shrinkage	
			Linear	Cubical**
		per cent	per cent	per cent
A	35.6	10.2	13.0	34.1
B	32.7	6.7	12.1	32.1
C	26.6	4.7	8.8	24.1
D	26.5	2.4	6.0	16.9
E	16.3	2.9	2.9	8.5

*Calculated from mechanical analysis by Briggs-Shantz formula.
**Calculated from linear shrinkage by Tempany's formula.

[1]Adapted from a portion of master's thesis submitted to the graduate school of the University of Minnesota. Approved as Journal Series Paper Number 1092 of the Minnesota Agricultural Experiment Station.

[2]Assistant professor of agricultural engineering (reclamation), University of Minnesota. Assoc. Mem. A.S.A.E.

[3]Figures in parenthesis refer to "Literature Cited" following this paper.

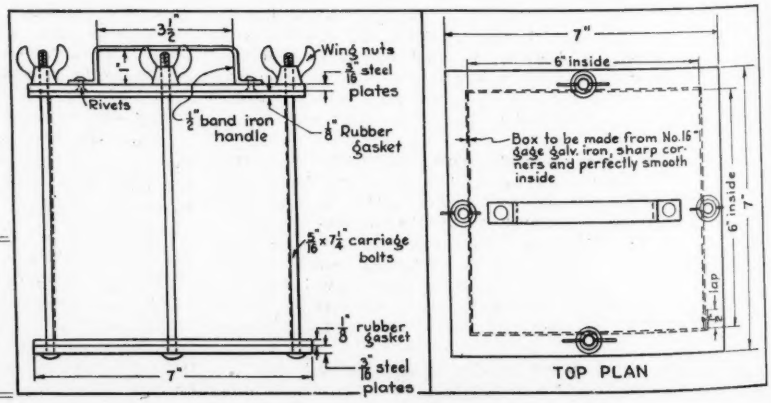


Fig. 1. The soil sample box used in the Minnesota studies of soil moisture relationships

TABLE II. MOISTURE EQUIVALENTS

Depth of sample feet	Aitkin-E			Aitkin-W			Meadowlands			Payneaville			Waseca		
	Set A	Set B	Set C	Set D	Set E	Set F	Set A	Set B	Set C	Set A	Set B	Set C	Set A	Set B	Set C
0.00-0.50	190.4	142.2	170.6	223.4	220.9	218.7	34.6	30.0	36.8	136.3	68.2	84.1	31.9	33.7	36.9
0.50-1.00	105.0	176.8	15.5	246.7	192.8	231.9	25.9	26.3	27.2	150.2	42.1	41.0	26.3	32.5	31.8
1.25-1.75	11.6	156.7	12.7	233.3	82.7	6.8	23.6	23.5	39.5	244.8	19.3	20.3	27.3	31.5	43.2
2.25-2.75	7.6	6.9	17.3	5.5	6.7	3.3	24.2	23.8	25.5	73.4	19.0	25.1	25.1	23.8	34.3
3.25-3.75	4.3	5.9	17.6	11.5	8.2	12.5	40.1	34.6	28.3	32.3	21.9	22.5	27.3	21.7	23.7

muck. A stratum of mucky clay from 6 to 12 inches in depth underlies the surface muck or peat. The thicker part of the stratum is under the deeper peat. A grayish loam underlies the mucky clay to a depth of more than 4 feet.

The Waseca soil was a silt loam, the surface being a light brown "heavy" silt loam, while the subsoil, below 4 feet, consisted of the unmodified gray boulder clay.

Method of Taking Samples. Each set of samples was taken about 10 feet from a tile line, far enough away to get undisturbed soil. From each field three sets of five 6-inch samples were taken, as follows: 0.0 to 0.5 foot, 0.5 to 1.0 foot, 1.25 to 1.75 feet, 2.25 to 2.75 feet, and 3.25 to 3.75 feet.

They were taken in iron boxes, inclosing 6-inch cubes, consisting of a square form, cover and bottom (Fig. 1). The four walls of the form were made of 0.054-inch or 16-gage sheet iron. The cover and bottom, which were detachable, were made of steel plates 3/16-inch thick and 7 inches square. The cover had a handle riveted on for carrying the box. Four ⅜-inch holes were drilled through the cover and the bottom, one midway between each of the corners and 1/16-inch from the edge. Rubber gaskets, of the same size as the cover and bottom and with the ⅜-inch holes in the corresponding positions, were fitted over the bottom and under the cover to prevent any water leaking out of the box. The cover and bottom were fastened in place by four 5/16-inch bolts, 7¼ inches long, put through the ⅜-inch holes in the cover and bottom but outside the walls of the box.

A block of soil about one foot square was left standing intact while the surrounding soil was spaded away to a depth of 6 inches. The form described above was driven down into the center of the block until flush with the surface. For the determination of the moisture equivalent a composite sample was taken from the portion of the square soil column surrounding the form. The latter was then dug out with a spade and the soil planed off above and below until just even with the edges of the box, using for this purpose a steel straight edge 12 inches long, 1.5 inches wide and 1/32-inch thick. Then the cover and bottom of the box were bolted on tight enough to prevent water draining out of the box. The trench was then deepened and the remaining samples of the set taken in the same manner.

Moisture Equivalent. The moisture equivalents of the samples were determined in duplicates and are reported in Table II. All moisture data are reported on the basis of moisture free soil. The values ranged from 3 to 43 in the case of the mineral soils, while in the case of the mucks and peats the values ranged from 68 to 247.

Determination of Properties of the Soil Cubes. When all the samples from a field had been taken, they were brought to the laboratory. Each box of soil was weighed. Then the top and bottom were removed and the box submerged in a jar of water and left there for 48 hours. At the end of this time the top and bottom were replaced, the box removed from the water, the moisture on the outside of the box wiped off with a dry cloth, and the box weighed again.

Next the top and bottom were loosened until there was an opening of ⅛ inch at both the bottom and the top. Then the box was laid on its side, allowed to drain for 48 hours, and weighed again. After this both cover and bottom were removed and the form with the enclosed soil placed in an electric oven at 100 to 110 degrees (centigrade) and left until it reached constant weight, about a week being required.

Then the perimeter of the cube of soil was measured at the top, the middle, and the bottom, and the average height determined. From these values the approximate volume was calculated by the formula for a prismoid

$$V = \frac{1}{6} h\ (B + B^1 + 4\ M)$$

in which V is volume, h is average height, B is the area of the base, B^1 is the area of the top, and M is the area at the center. Assuming that the original volume was the same as that of the box, the percentage of shrinkage was calculated, but it should be mentioned that a few interior cracks lessened the exactness of the determination.

Density. The weight per cubic foot of the moisture-free soils varied from 11 to 115 pounds (Table III). This extreme variation was found on the Aitkin field where there was a peat layer on the surface and an almost pure sand at 3 to 4 feet below. In the case of the moisture-free mineral soils, there is a fairly close relationship between the moisture equivalent and the weight per cubic foot, the index of correlation being 0.92 (Fig. 2), while in the case of the mucks and peats there is no consistent relationship.

The density of the soil when all the pore spaces were occupied by water is given in Table IV. The range in the case of the saturated soil was not as great as in the moisture-free soil. The minimum density in the saturated condition was approximately the same as that of water. This would be expected since a saturated peat contains 80 per cent or more of water by wet weight while a saturated sand carries only about 14 per cent.

The specific gravity of the soil material as given in Table V was determined from the density of the moisture-free soil given in Table III and the per cent of pore space given in Table VII.

$$\text{Specific gravity} = \frac{\text{weight of moisture free soil}}{\%\text{ of volume occupied by soil x 6 2.5}}$$

The specific gravity of the peat and muck soils varied from 1.0 to 2.0 depending upon the amount of mineral matter present. In the peat soils, which contain only a small amount of mineral matter, the specific gravity was from 1.0 to 1.2. With those of the mineral soils that were practically free from organic matter, it ranged from 2.5 to 2.7.

Moisture Content of Soil Cubes After 48 Hours Submergence. The percentages of moisture in the submerged blocks of soil on a weight basis, and the ratio of this to the moisture equivalent are given in Table VI. The average ratio for all the samples was 1.6.

The ratios for the Aitkin soils ranged from 0.6 to 5.1, a much wider variation than with any of the following. The ratio for all averaged 2.0, that for the peat layer averaging 1.4 and that for the mineral subsoil 2.5. The ratio for the surface 6 inches of set C of Aitkin-E is exceptionally low. Since the peat was very shallow and contained diagonal seams of almost pure sand, it is quite likely that the sample from which the moisture equivalent was determined contained more peat than the sample from which the moisture content was determined.

For the Meadowlands soils the average ratio was 1.2, and if the first

TABLE V. SPECIFIC GRAVITY OF SOIL MATERIAL

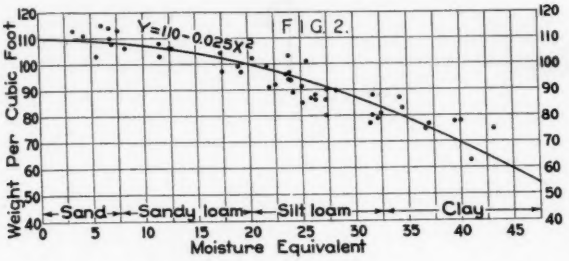
Depth of sample feet	Aitkin-E			Aitkin-W			Meadowlands			Payneaville			Waseca		
	Set A	Set B	Set C	Set D	Set E	Set F	Set A	Set B	Set C	Set A	Set B	Set C	Set A	Set B	Set C
0.00-0.50	1.09	1.10	1.02	1.18	1.12	1.12	2.27	2.32	2.49	1.30	1.72	1 73	2.30	2.30	2.42
0.50-1.00	1.93	1.04	2.12	1.44	1.05	1.00	2.56	2.48	2.56	1.31	2.00	2.56	2.43	2.50	2.63
1.25-1.75	2.54	1.16	2.45	1.38	1.94	2.51	2.65	2.62	2.50	1.30	2.58	2.60	2.51	2.55	2.64
2.25-2.75	2.64	2.59	2.59	2.66	2.61	2.62	2.62	2.62	2.59	2.00	2.57	2.59	2.56	2.56	2.64
3.25-3.75	2.66	2.64	2.58	2.61	2.62	2.67	2.65	2.58	2.63	2.50	2.58	2.55	2.60	2.56	2.74

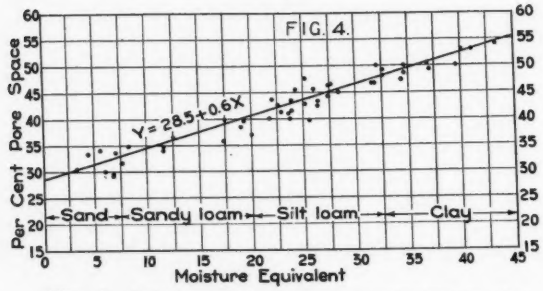
TABLE IV. DENSITY OF SOILS WITH ALL PORE SPACES OCCUPIED BY WATER
Expressed as weight per cubic foot

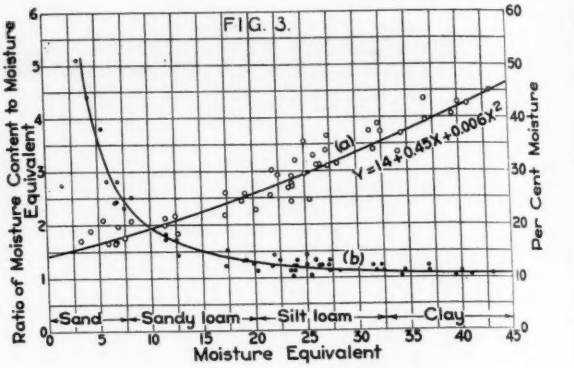
Depth of sample feet	Aitkin-E			Aitkin-W			Meadowlands			Payneaville			Waseca		
	Set A	Set B	Set C	Set D	Set E	Set F	Set A	Set B	Set C	Set A	Set B	Set C	Set A	Set B	Set C
0.00-0.50	64	64	63	65	64	64	102	103	107	66	74	76	102	98	107
0.05-1.00	82	63	101	64	62	63	116	115	115	66	82	99	107	104	117
1.25-1.75	125	66	125	66	82	129	121	122	91	65	122	125	109	109	111
2.25-2.75	132	128	127	127	133	133	118	128	126	82	123	114	118	119	116
3.25-3.75	132	134	122	129	128	129	111	113	116	110	118	118	117	123	128

TABLE III. DENSITY OF MOISTURE FREE SOILS
Expressed as weight per cubic foot

Depth of sample feet	Aitkin-E			Aitkin-W			Meadowlands			Payneaville			Waseca		
	Set A	Set B	Set C	Set D	Set E	Set F	Set A	Set B	Set C	Set A	Set B	Set C	Set A	Set B	Set C
0.00-0.50	19	22	31	15	17	12	71	72	75	17	29	32	70	65	77
0.50-1.00	40	24	72	12	16	11	67	68	66	14	39	63	66	81	68
1.25-1.75	103	27	106	14	40	110	98	96	78	13	97	102	80	80	75
2.25-2.75	113	107	104	103	114	113	89	96	101	29	99	85	91	94	87
3.25-3.75	111	115	97	108	106	108	78	83	90	79	91	92	90	99	103







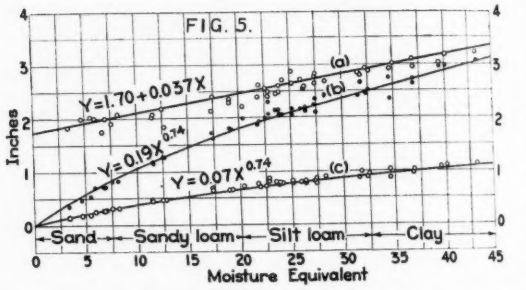


Fig. 2. Relation of the moisture equivalent to the weight per cubic foot of soil

Fig. 3. Moisture relationships of soils. (a) Moisture content of submerged blocks of soil — per cent by weight. (b) Ratio of the moisture content of submerged block of soil to the moisture equivalent

Fig. 4. Total pore space of soils—per cent by volume

Fig. 5. The amount of rainfall that six-inch layers of moisture free mineral soil would require to bring its moisture content to (a) complete saturation, (b) the moisture equivalent, and (c) the hygroscopic coefficient

6 inches, which contain considerable organic matter, be omitted, it becomes 1.1. The maximum amount of water which this soil would hold was only slightly above the moisture equivalent.

For the Paynesville soils the average ratio was 1.6, for the peat and muck layers 2.1, and for the mineral subsoil 1.3. The peat layer at the Paynesville field differed from that on the Aitkin field in that considerable mineral matter had been deposited along with the peat in the process of formation. This made the moisture equivalent lower, but the ratio of the water content to the moisture equivalent higher.

With the Waseca sets, the ratios for the first foot are much higher than for the deeper layers, the average being 1.4 for the surface foot and 1.1 for the subsoil. This may be attributed to the high content of organic matter in the surface soil. The water content of the saturated subsoil ranged from 1.1 to 1.3 times the moisture equivalent.

The values for the moisture content of the submerged blocks of mineral soils and the ratios of the above moisture content to the moisture equivalent are plotted in Fig. 3.

There is a very uniform increase in the water content of the saturated mineral soils with an increase in the moisture equivalent. The relationship is given by the equation

$$M_s = 14 + 0.45X + 0.006X^2$$

in which M_s = water content of the saturated soil expressed as per cent of dry weight

and X = moisture equivalent.

The index of correlation[4] is high, being 0.96. The standard deviation[5] (σ) is 8.03 and the standard error[6] (S) is 2.35.

[4]Index of correlation corresponds to coefficient of correlation, except that it is used in non-linear correlation while the latter is for linear correlation.

[5]The root-mean-square of deviations from the mean.

[6]The root-mean-square of deviations of the actual M_s values from the computed M_s values. Approximately 68 per cent of all the cases fall within a range of $\pm S$ and 95 per cent of all cases in a range of $\pm 2S$.

The graph of the ratio of the moisture content to the moisture equivalent has the shape of a hyperbola. As the moisture equivalent increases, the ratio decreases, the decrease being very rapid at first until a moisture equivalent of about 20 is reached, but from that point on the change is very much slower. When the moisture equivalent was 20, the ratio was about 1.2. When the former increased to 40, the ratio decreased to about 1.1. If the moisture equivalent continued to increase, the ratio would continue about 1.0, provided the samples were of mineral soils.

The ratios of the moisture content of submerged blocks of muck or peat soils to the moisture equivalents are so irregular that no generalization can be made. The ratio is higher for muck than for peat soils, but is higher for peats with a high moisture equivalent than for peats with a low moisture equivalent.

Pore Space. The actual pore space, given in Table VII was determined from the volume of water held by the soil when all the pores were filled. It is the same as the percentage of water in a saturated soil expressed on a volume basis. In the mineral soils the pore space shows a fairly uniform increase as the value for the moisture equivalent increases (Fig. 4). The average increase is a straight line relationship to the moisture equivalent with a slope of 0.6, the equation for the relationship being

$$P = 28.5 + 0.6X$$

in which P = pore space and X = moisture equivalent.

The standard error (S) is 1.73 while the standard deviation (σ) is 7.32. The coefficient of correlation

$$\sqrt{1 - \frac{S^2}{\sigma^2}} = 0.97$$

TABLE XI. THE MOISTURE CONTENT OF SUBMERGED BLOCKS OF SOIL

Depth of section feet	Aitkin-2			Aitkin-W			Meadowlands			Paynesville			Waseca		
	Set A	Set B	Set C	Set D	Set E	Set F	Set A	Set B	Set C	Set A	Set B	Set C	Set A	Set B	Set C
Moisture content of submerged blocks of soil - percentage by weight															
0.00-0.50	235.8	198.6	99.9	326.4	276.6	412.5	44.0	43.8	43.3	286.9	160.6	138.5	44.6	52.4	39.4
0.50-1.00	106.2	166.0	39.3	437.4	288.7	451.1	32.6	30.7	33.6	359.6	108.1	42.6	30.8	37.1	33.8
1.25-1.75	21.0	144.2	18.0	387.1	104.7	16.6	28.8	26.7	40.2	403.9	25.4	22.6	36.4	37.2	45.0
2.25-2.75	17.6	19.6	21.4	20.7	16.2	16.9	31.8	27.0	24.4	163.4	24.3	35.2	29.2	27.5	33.4
3.25-3.75	14.8	16.3	25.8	19.7	20.5	21.8	42.6	36.7	31.1	38.6	30.0	29.0	30.7	25.5	24.1
Ratio of the moisture content to the moisture equivalent															
0.00-0.50	1.2	1.4	0.6	1.5	1.3	1.9	1.3	1.5	1.2	2.1	2.4	1.6	1.4	1.6	1.1
0.50-1.00	1.0	0.9	2.5	1.8	1.5	2.1	1.3	1.2	1.2	2.2	2.6	1.0	1.2	1.1	1.1
1.25-1.75	1.2	0.9	1.4	1.7	1.3	2.4	1.2	1.1	1.0	1.6	1.3	1.1	1.3	1.2	1.0
2.25-2.75	2.3	2.8	1.2	3.8	2.4	2.1	1.3	1 1	1.0	2.2	1.3	1.4	1.2	1.2	1.0
3.25-3.75	4.4	2.8	1.5	1.7	2.5	1.7	1.1	1.1	1.1	1.2	1.4	1.3	1.1	1.2	1.0

TABLE VII. PORE SPACE OF BLOCKS OF SOIL

Actual pore space as percentage of total volume occupied by soil

Depth of section feet	Aitkin-E			Aitkin-W			Meadowlands			Paynesville			Waseca		
	Set A	Set B	Set C	Set D	Set E	Set F	Set A	Set B	Set C	Set A	Set B	Set C	Set A	Set B	Set C
0.00-0.50	71.9	68.6	50.3	79.4	75.6	62.2	50.0	50.4	51.9	78.9	73.4	70.5	50.0	54.3	49.2
0.50-1.00	67.2	63.4	49.5	83.3	73.6	61.9	49.5	51.2	46.8	82.5	68.3	63.0	47.4	48.0	42.7
1.25-1.75	34.8	62.5	30.6	84.2	66.9	29.6	43.3	41.1	50.1	84.0	39.6	36.9	46.4	47.6	43.0
2.25-2.75	31.7	33.6	35.7	34.1	29.7	30.6	45.5	41.5	39.7	76.1	38.2	47.7	42.8	41.2	47.2
3.25-3.75	33.3	30.0	32.9	33.9	34.9	36.4	55.0	48.6	44.9	49.1	43.6	42.5	44.2	40.0	40.0

TABLE IX. CONTRACTION IN VOLUME OF SOIL CUBES ON DRYING

Percentage calculated on basis of volume of cubes as taken in field

Depth of section feet	Aitkin-E			Aitkin-W			Meadowlands			Paynesville			Waseca		
	Set A	Set B	Set C	Set D	Set E	Set F	Set A	Set B	Set C	Set A	Set B	Set C	Set A	Set B	Set C
0.00-0.50	34.0	25.6	29.5	32.0	29.1	30.9	13.7	15.6	16.0	30.1	22.2	22.1	7.9	17.2	6.6
0.50-1.00	27.5	33.2	10.3	29.6	30.9	32.1	12.7	17.7	18.2	30.2	16.7	9.0	7.9	11.5	10.0
1.25-1.75	0.5	36.0	3.8	33.0	31.0	1.3	7.5	12.7	18.2	37.7	5.8	3.5	2.5	15.7	14.5
2.25-2.75	0.8	0.9	3.4	3.8	0.2	0.2	7.3	5.6	7.0	26.2	2.9	5.8	5.4	9.0	7.5
3.25-3.75	3.8	2.1	7.4	4.2	0.6	1.7	20.3	18.6	9.8	14.1	3.9	5.3	7.4	3.3	6.9

TABLE VIII. WATER LOST FROM ISOLATED SATURATED BLOCKS OF SOIL BY FREE DRAINAGE FOR 48 HOURS

Depth of section feet	Aitkin-E			Aitkin-W			Meadowlands			Paynesville			Waseca		
	Set A	Set B	Set C	Set D	Set E	Set F	Set A	Set B	Set C	Set A	Set B	Set C	Set A	Set B	Set C
Loss of water by drainage during 48 hours - percentage by weight															
0.00-0.50	9.3	13.9	6.1	8.7	21.9	32.8	3.3	0.9	4.1	17.6	4.3	3.4	1.6	4.8	1.9
0.50-1.00	3.0	4.1	1.7	14.6	10.7	44.0	3.3	2.3	4.8	15.0	3.3	4.9	1.7	7.4	2.5
1.25-1.75	0.4	1.1	1.2	21.4	5.5	0.7	0.6	0.7	3.5	8.5	2.8	2.5	1.4	3.6	1.3
2.25-2.75	0.5	0.4	0.4	1.2	1.0	1.0	0.6	0.5	1.0	4.1	2.0	1.9	1.7	2.0	1.8
3.25-3.75	0.3	0.5	0.6	0.8	1.0	0.9	1.1	1.1	0.9	1.4	2.8	2.1	2.0	2.1	0.8
Decrease in ratio of moisture content to moisture equivalent															
0.00-0.50	0.0	0.1	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.2	0.1
0.50-1.00	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
1.25-1.75	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.0
2.25-2.75	0.0	0.0	0.0	0.2	0.1	0.3	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1
3.25-3.75	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.1	0.1	0.1	0.0
Loss of water by drainage during 48 hours - percentage by volume															
0.00-0.50	2.8	4.8	3.1	2.1	5.9	6.4	3.8	1.1	5.0	4.9	2.0	1.7	1.9	5.1	2.4
0.50-1.00	1.9	1.6	2.0	2.8	2.7	7.9	4.6	3.3	6.5	3.4	2.1	4.5	2.1	8.4	3.4
1.25-1.75	0.2	0.5	2.0	4.6	3.5	1.3	0.9	1.1	4.2	1.8	4.4	4.0	2.8	4.6	1.6
2.25-2.75	0.8	0.6	0.7	2.1	1.8	1.7	0.9	0.8	1.6	1.9	3.2	2.7	2.8	2.9	2.6
3.25-3.75	0.5	0.8	0.8	1.3	1.7	1.4	1.3	1.6	1.3	1.8	4.1	3.0	2.9	3.2	1.4

which value indicates a definite and close relationship between the two variables.

In the muck and peat soils the pore space was not a direct function of the moisture equivalent. There was not much difference between the pore space in the muck soils and that in peat soils when the moisture equivalents were below 200. However, there was considerably more pore space in the peats with a moisture equivalent above 200. As a general rule the higher the organic matter content the greater was the amount of pore space.

Loss of Water from Saturated Blocks of Soil. The moisture content lost by draining for 48 hours is reported in Table VIII both by weight and by volume. The ratio of the loss of moisture to the moisture equivalent was computed and found to vary only from 0.0 to 0.3, with an average of 0.1 as shown in Table VIII.

Contraction of Soil Cubes on Drying. The difference between the volume of the oven-dry cubes, determined as described above, and the original volume, considered the same as that of the boxes in which they were taken, is the loss in volume on drying—the contraction—and is reported in Table IX. In the case of the muck and peat soils, there is very little correlation between the contraction, the moisture equivalent, the density, and the organic-matter content.

Moisture Content in the Field. The field moisture content at the time of sampling is given in Table X. The monthly precipitation record from the first of the year up to the time of taking the samples is given in Table XI. On the volume basis percentage of moisture varied from 22.5 to 74.8. In the very sandy soils about 33 per cent of the volume was occupied by water, in the silty loam soils about 40 per cent, and in the peaty soils from 29 to 75 per cent.

There was a much wider range in the percentages by weight, which ranged from 15 to 384.

The Aitkin-E samples were taken in mid-summer while there was a heavy crop of potatoes and timothy on the land, but the Aitkin-W samples at the end of September, after all the crops had matured. There was a 3.5-inch rain 6 to 7 days before the Aitkin-E samples were taken and an 0.83-inch rain 10 days before the Aitkin-W samples were taken. The effect which the crops have upon the moisture content in the upper 6 inches is very evident from a comparison of Sets A, B, and C with Sets D, E, and F. The average ratio for the peat soil of Aitkin-E was 0.8 and of Aitkin-W 1.3. The respective ratios for the mineral soils were 2.2 and 2.7, while the ranges were respectively 1.2 to 4.3 and 1.6 to 4.8. In each case the highest ratio corresponded to the lowest moisture equivalent. The height above the water table had no appreciable effect upon the ratio, while a change in texture had a very marked effect. Sample 3 of Set A had nearly the same moisture content as Sample 5 of Set D. Their ratios also were about the same. The former was 1.1 feet above the water table while the latter was 1.1 feet below. Sample 4 of Set E corresponded in a similar way with Sample 3 of Set F. The former was 1 foot and the latter 2 feet above the water table.

The ratio of the moisture content to the moisture equivalent for the Meadowlands soils averaged 1.0, with a range from 0.9 to 1.4. The height above the water table had no apparent effect upon the ratio. In fact, there was no increase when the samples were taken from below the water table. As there had been a rain of 0.28 inch the night before the samples were taken, the ratio was 1.0 or above in the surface 6 inches. In the upper 6 inches of Set B, the ratio was 1.4, which was higher than with any other samples taken at Meadowlands.

The average ratio for the Paynesville soil was 1.3, with a range from 0.9 to 2.1. The high ratios were found in the mucky clay layer under the peat or muck. The average ratio for the mineral soil was 1.1. There had been a trace of rain early in the morning before the samples were taken but not enough to materially affect the soil-moisture content. It will be noticed (Table X) that the ratios of the upper 6 inches were above 1.0, and yet there had been less than 0.5 inch of rain in the previous 3 weeks. The samples were taken in the fall after the crop had been harvested.

The average ratio of the field moisture content to the moisture equivalent of the Waseca samples was much lower than for any of the other samples. These samples were taken in early July during a prolonged dry spell, the precipitation for June being about half the normal fall. The average ratio was 0.8 with a range from 0.6 to 1.1. Only two samples showed a higher moisture content than the moisture equivalent.

Amount of Water Required to Bring the Soil to Different Stages of Moistness. In Table XII is shown the amount of rain that the moisture-free soils would require to bring their water content to various stages of moistness—to the hygroscopic coefficient, to the moisture equivalent, and to complete saturation. At the last stage all the pore spaces would be completely occupied by water.

As the moisture equivalent increased, there was a fairly uniform increase in the amount of rain required to bring the mineral soils to the different degrees of moistness.

TABLE X. MOISTURE CONTENT OF THE SOILS IN THE FIELD

Depth of section feet	Aitkin-E			Aitkin-W			Meadowlands			Paynesville			Waseca		
	Set A	Set B	Set C	Set D	Set E	Set F	Set A	Set B	Set C	Set A	Set B	Set C	Set A	Set B	Set C
Distance of bottom of sample above (+) or below (-) ground water surface, in feet															
0.00-0.50	+2.3	+2.6	+3.0	+2.1	+3.2	+3.2	+2.5	+2.0	+1.5	Ground water table over 5 feet below the surface of the ground					
0.50-1.00	+1.8	+2.1	+2.5	+1.6	+2.7	+2.7	+2.0	+1.5	+1.0						
1.25-1.75	+1.1	+1.4	+1.8	+0.9	+2.0	+2.0	+1.3	+0.8	+0.3						
2.25-2.75	+0.1	+0.4	+0.8	-0.1	+1.0	+1.0	+0.3	-0.2	-0.7						
3.25-3.75	-0.9	-0.6	-0.2	-1.1	0	0	-0.7	-1.2	-1.7						
Moisture content in field - percentage by weight															
0.00-0.50	175.5	128.7	56.9	307.3	172.5	298.9	35.0	41.1	38.0	159.3	113.8	58.7	29.7	37.0	27.2
0.50-1.00	91.9	144.4	26.9	384.3	257.9	330.6	26.0	25.9	27.1	210.7	86.4	43.2	22.5	32.6	20.9
1.25-1.75	20.1	134.9	15.1	341.8	93.5	14.8	27.7	25.3	34.5	292.4	21.1	17.7	17.6	32.6	34.6
2.25-2.75	17.8	19.1	20.4	21.5	15.2	16.0	30.2	20.3	23.2	151.9	20.6	31.3	16.4	21.1	26.2
3.25-3.75	18.9	15.7	24.5	18.9	19.6	20.9	36.8	33.5	30.1	37.0	25.5	25.6	24.4	20.0	21.6
Ratio of the moisture content to the moisture equivalent															
0.00-0.50	0.9	0.9	0.3	1.4	0.8	1.4	1.0	1.4	1.0	1.2	1.7	1.0	0.9	1.1	0.7
0.50-1.00	0.9	0.8	1.7	1.6	1.3	1.6	1.0	1.0	1.0	1.3	2.1	1.1	0.9	1.0	0.7
1.25-1.75	1.7	0.9	1.2	1.5	1.1	2.2	1.2	1.1	0.9	1.2	1.1	0.9	0.6	1.0	0.8
2.25-2.75	2.3	2.8	1.2	3.9	2.3	3.4	1.2	0.9	0.9	2.1	1.1	1.2	0.7	0.9	0.8
3.25-3.75	4.3	2.7	1.4	1.8	2.4	1.7	1.0	1.0	1.1	1.1	1.2	1.1	0.7	1.0	0.9

Table XI. Monthly Precipitation Record from First of Year to Time of Sampling

Month	Aitkin[a] 1928	Meadowlands 1928	Paynesville 1928	Waseca 1929
January	0.30	0.52	0.29	2.09
February	0.24	0.25	0.71	1.13
March	0.52	0.30	0.64	1.69
April	1.38	1.78	1.53	3.23
May	1.52	0.55	0.87	2.73
June	3.89	5.37	3.64	2.28
July	5.47	5.79*	4.92	1.36*[b]
August	4.23**		3.54	
September	5.80***		3.18	
October			0.46*[b]	

[a]Record for Sandy Lake Dam 25 miles northeast of Aitkin
[b]For the first eleven days of month
*Month samples were taken
**Month Aitkin-E samples were taken
***Month Aitkin-W samples were taken.

While there was no uniformity in the case of the mucks and peats, the mucks and peats required the greater amount of water. The averages for those of the peats with moisture equivalents between 136 and 200 were about the same as the averages for those with moisture equivalents between 200 and 245. For the mucks the averages were lower than for the peats but not in proportion to the difference in the moisture equivalents.

The curves for the amount of rain required to bring the moisture content of the mineral soils up to the computed hygroscopic coefficient and to the moisture equivalent are parabolas, these tending to flatten out when the moisture equivalent rises above 15. The graph showing the amount of rain required to fill all the pore spaces of the soils is a straight line (Fig. 5).

The total amount of water in the first foot and the first four feet of soil, when the moisture content is at the moisture equivalent, has been calculated for each of the four sites sampled.

	First foot	First 4 feet
Aitkin	4.3 inches	9.6 inches
Meadowlands	4.1 inches	12.3 inches
Paynesville	2.7 inches	10.4 inches
Waseca	5.0 inches	14.4 inches

SUMMARY

Fifteen sets of 6-inch cubes of soil were taken to a depth of 4 feet at four places, and in the case of each sample the following determinations made: Moisture content (a) as taken in the field, (b) after submergence in water for 48 hours, (c) after draining 48 hours following submergence; decrease of volume upon drying; and weight per cubic foot in situ. On disturbed samples, taken to correspond to the cubes, determinations were made of the moisture equivalent.

The moisture equivalent of the mineral soils varied from 3, in the case of the coarsest sand, to 43, in the case of the clay, while the muck and peat soils varied from 68 to 247. Those soils with less than 20 per cent organic matter were considered as mineral, those containing from 20 to 50 per cent as mucks, and those containing over 50 per cent as peats.

The moisture content of the submerged blocks of mineral soil varied from 0.9 to 5.1 times the moisture equivalent, while that of the muck and peat soils varied from 0.6 to 2.6, but in the case of the mineral soils with a moisture equivalent above 20 the ratio varied only between 0.9 and 1.5. The moisture content of the submerged blocks of mineral soil varied as the moisture equivalent, while in the case of the muck and peat soils, there was no definite relationship between the two values. The graph of the ratio of the moisture content to the moisture equivalent has the shape of a hyperbola. As the moisture equivalent increases, the ratio decreases, the decrease being very rapid at first until a moisture equivalent of about 20 is reached, but from that point on the change is very much slower, the average decrease in the ratio being about 0.2 when the value for the moisture equivalent increases from 20 to 40.

The pore space of the mineral soils varied from 29 to 56 per cent, while in some of the peat soils it rose as high as 84 per cent. Since the pore space corresponds to the saturated water content, expressed on a volume basis, it bears a similar relationship to the moisture equivalent.

When the cubes were allowed free drainage for 48 hours the loss of water was slight, and bore no definite relation to the moisture equivalent. In the case of the mineral soils this loss varied from 0.3 to 4.8 per cent of the weight of the dry soil, while with the peats it was higher, reaching a maximum of 44 per cent. The ratio of the loss of water to the moisture equivalent varied from 0.0 to 0.3.

On drying, the contraction of the cubes varied from 0.2 to 20 per cent with the mineral soils and up to 38 per cent with the peat. There was a general relationship between shrinkage and the moisture equivalent, the shrinkage increasing as the moisture equivalent increased.

TABLE XII RAINFALL REQUIRED TO BRING 6 INCH LAYERS OF THE WATER FREE SOIL TO VARIOUS DEGREES OF MOISTURES

Depth of section feet	Aitkin-E Set A	Aitkin-E Set B	Aitkin-E Set C	Aitkin-F Set D	Aitkin-F Set E	Aitkin-F Set F	Meadowlands Set A	Meadowlands Set B	Meadowlands Set C	Paynesville Set A	Paynesville Set B	Paynesville Set C	Waseca Set A	Waseca Set B	Waseca Set C
Inches of rain required to bring the soil to the computed hygroscopic coefficient															
0.00-0.50	1.28	1.11	1.68	1.19	1.33	0.97	0.87	0.77	0.98	0.82	0.70	0.95	0.79	0.74	1.00
0.50-1.00	1.49	1.50	0.79	1.04	1.10	0.85	0.80	0.82	0.83	0.83	0.58	0.92	0.80	0.94	1.00
1.25-1.75	0.42	1.50	0.48	1.12	1.17	0.26	0.79	0.80	1.09	1.13	0.66	0.73	0.77	0.89	1.15
2.25-2.75	0.30	0.27	0.64	0.20	0.27	0.13	0.76	0.81	0.91	0.75	0.66	0.76	0.81	0.79	1.06
3.25-3.75	0.17	0.24	0.60	0.45	0.31	0.17	1.11	1.02	0.91	0.90	0.71	0.73	0.87	0.76	0.87
Inches of rain required to bring the soil to the moisture equivalent															
0.00-0.50	3.47	3.00	5.08	3.22	3.50	2.62	2.36	2.07	2.65	2.22	1.90	2.58	2.05	2.09	2.73
0.50-1.00	4.03	3.61	1.07	2.81	2.95	2.31	2.16	2.22	2.24	2.26	1.57	2.46	2.17	2.52	2.68
1.25-1.75	1.15	4.07	1.29	3.03	3.17	0.72	2.15	2.16	2.96	3.05	1.79	1.99	2.09	2.42	3.10
2.25-2.75	0.82	0.71	1.73	0.54	0.73	0.36	2.06	2.19	2.47	2.04	1.80	2.05	2.19	2.14	2.88
3.25-3.75	0.46	0.65	1.62	1.19	0.83	1.27	2.99	2.75	2.46	2.45	1.91	1.99	2.36	1.68	2.34
Inches of rain required to fill all pore spaces with water															
0.00-0.50	4.28	4.20	2.98	4.71	4.52	4.93	3.00	3.03	3.11	4.68	4.46	4.25	3.00	3.26	2.95
0.50-1.00	4.07	3.83	2.72	5.00	4.43	4.91	2.72	2.99	2.77	4.95	4.05	3.18	2.54	2.88	2.80
1.25-1.75	2.07	3.78	1.83	5.05	4.02	1.75	2.60	2.46	3.01	5.04	2.36	2.20	2.78	2.65	3.24
2.25-2.75	1.91	2.01	2.14	2.04	1.77	1.45	2.71	2.49	2.36	4.54	2.31	2.87	2.65	2.48	2.88
3.25-3.75	2.00	1.80	2.40	2.04	2.04	2.18	3.18	2.52	2.68	2.53	2.62	2.56	2.65	2.40	2.40

To bring a 6-inch layer of the moisture-free soil in its undisturbed natural position to the moisture equivalent would require from ⅓ inch of rain, with the coarsest sands, to 3 inches with the finest textured mineral soils, while with the peats in some cases it was as high as 5 inches. To fill all the pore spaces with water would require from 2 to 5 inches of rain per 6-inch layer of soil.

CONCLUSIONS

The moisture content of the saturated mineral soils and their pore space show a fairly definite relationship to the moisture equivalent. The moisture content of moderately fine-textured soils in situ lying below the water table varies between 1.0 and 1.4 times the moisture equivalent, while that for the coarser textured soils may exceed five times the moisture equivalent. Free drainage of small detached soil masses that have been saturated with water causes very little loss with the result that their final moisture content is far in excess of that of soils in capillary connection with the earth's soil mass.

Since the moisture equivalent represents the approximate normal water-holding capacity of the fine-textured soils, those with a moisture equivalent above 20, the amount of irrigation water applied should not exceed this amount for the root zone. In the case of the coarser textured soils, the normal water-holding capacity is from 1.5 to 3 times the water content at the moisture equivalent, the ratio becoming higher as the soil becomes coarser.

Only the water in excess of the normal water capacity is free to move to drains or the deep subsoil. The soil-moisture relationships found in this study are similar to those found by Harding (6), but an exact comparison can not be made since different conditions were studied.

(AUTHOR'S NOTE: The author wishes to acknowledge the assistance of Professor H. B. Roe in preparing this paper and the advice of Dr. F. J. Alway in the laboratory studies and the analysis of the data.)

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The Symbolism of the Cyrus Hall McCormick Medal

JUST a year ago this month the American Society of Agricultural Engineers was made the recipient of a generous gift in money with which to establish a permanent endowment for a gold medal to be awarded each year by the Society. The purpose of the donors — Mr. Cyrus H. McCormick, Mrs. Emmons Blaine, and Mr. Harold F. McCormick — in making such an award possible, was to honor their father, Cyrus Hall McCormick, the inventor of the reaper. The award will be known as the "Cyrus Hall McCormick Medal," and it will be awarded annually by the Society — according to the wording on the reverse side of the medal — "for exceptional and meritorious engineering achievement in agriculture."

The medal was designed by Mr. Fred H. Torrey, a Chicago sculptor, in cooperation with Col. Oliver B. Zimmerman, a past-president of the American Society of Agricultural Engineers.

The Society was most fortunate in the selection of a sculptor; Mr. Torrey received his training at the Art Institute of Chicago and as an assistant to Mr. Lorado Taft, the famous Chicago sculptor. Both by training and experience, therefore, he was eminently qualified to execute the design for the McCormick medal.

Mr. Torrey entered upon his task with great enthusiasm and keen interest. He devoted much time to an intensive study of the subject before him, arriving at the conception of his design with great care and deliberation. In fact, the Society can never hope to adequately repay Mr. Torrey for the abundance of time, energy, and interest which he has put into the execution of this medal.

However, the result of Mr. Torrey's inspiration for his task and his painstaking attention to its execution is reflected in the design of the medal. On this page is a photographic reproduction of the models of the observe and reverse sides of the medal, which unfortunately fails to bring out satisfactorily the beauty of the sculptor's conception and the excellence of detail.

Members of the American Society of Agricultural Engineers in particular will be interested in the symbolism treated in the McCormick medal. It is a fascinating story, and we are fortunate in having Mr. Torrey himself tell it, in the following paragraphs:

> "There having been such rapid advancement in the science of agriculture and agricultural engineering, a wide field of inspirational material was offered the sculptor in designing a medal of this kind. A number of designs were made and presented to Col. Zimmerman and his committee, some of which included a portrait of Mr. McCormick. But it was thought best not to use the portrait on account of there having been struck in large quantities a centennial medal bearing this portrait. This decision was further influenced by the fact that the authorized portrait of Mr. McCormick was of a man of advanced years, while at the time of the invention of the reaper he was a much younger man. It was then proposed to have the obverse of the medal contain a symbol or symbolic treatment.
>
> "Therefore, the symbolism treated on the obverse side of the medal is that of the figure of a man posed similar to that of Rodin's Thinker. The thinker, or inventor in this instance, is seated gazing reflectively at the old-fashioned cradle used for the harvesting of grain. The handle of the cradle rests in his lap and under his left arm. The blade and the teeth of the cradle conform to the circular pattern of the lettering which forms the border of the medal. The figure alone as it is here treated would leave the field of this side of the medal rather bare of ornament. In order to add interest to this side and to fill in the remaining space around the thinker, conventionalized stalks of wheat were used, radiating from the center of the medal — the heads of the wheat almost touching the lettering, while the points of the leaves touching one another for a scalloped border around the figure. At the feet of the thinker lies a branch of laurel in recognition of the victor, or the victorious achievement.
>
> "There being such a wide range of material from which to select, it seemed that there should be a symbol also for the reverse side of the medal, the scope of which would extend from the ages past down to the time of the invention of the reaper.
>
> "The Bible is rich in references to the toilers on the threshing floor; the reapers, the gleaners, and the sowers, and for this reason the sculptor instinctively turned to it for a theme. There is a very beautiful picture of the harvest in the story of Boaz and the threshing floor, and of Ruth and her companions gleaning in the fields. So much of interest was found that it was thought best to have the large figure in the center foreground of the reverse side symbolize the toiler with the flail threshing the harvested wheat. Strangely enough this method of harvesting extended down through the centuries even to Mr. McCormick's time, and is practiced in some countries today. In the luxuriant growth of wheat in the middle ground are the harvesters with their old-fashioned sickles, and following them are gleaners, while in the distance is the dawning of this new era of the horse-drawn "self-rake," or the "reaper" — the sweeps of the reaper rising and radiating with the rays of the sun.
>
> "Thus, to sum up the symbolisms of the Cyrus Hall McCormick medal, the world of back-breaking toil of the harvest that has existed through the ages is relieved by this new invention of Mr. McCormick's, the reaper and its later developments."

Obverse

Reverse

A photographic reproduction (exact size) of the Cyrus Hall McCormick gold medal to be awarded annually by the American Society of Agricultural Engineers "for exceptional and meritorious engineering achievement in agriculture." The medal was designed by Mr. Fred M. Torrey, sculptor

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Agricultural Machines, K. Vormfelde (Handbuch der Landwirstschaft. Band III, Pflanzenbaulehre. Landmaschinen. Berlin: Paul Parey, 1930, vol. 3, [sup.], pp. 220, pls. 8, figs. [249])—This is a technical treatise on farm machinery, dealing with its development, design, testing and proper adaptation. It covers practically every type of machine used in German agriculture and is profusely illustrated from the standpoints of both technological development and practical use.

Earth Pressure Tables [trans. title], E. R. Schubert (Bauingenieur 11 (1930), No. 7, pp. 113, 114, figs. 3; abs. in [Great Britain] Department of Science and Industrial Research (London) Building Science Abstracts, n. ser., 3 (1930), No. 4, p. 139). Tables based on Coulomb's theory of earth pressures are given for facilitating the calculation of the earth pressure, the pressure on the wall, and the moment at the heel of L-shaped retaining walls under various types of loading.

A Comparative Study of Alcohol, Gasoline, and Kerosene, as Fuels for Tractor Engines, A. L. Teodoro (Philippine Agriculture (Los Banas), 20 (1931), No. 5, pp. 295-327, figs. 10).—Studies conducted at the New York Cornell Experiment Station on the comparative values of alcohol, gasoline and kerosene for tractor engines are reported. The studies involved 157 tests. Straight alcohol of different percentages and diluted and undiluted denatured alcohol were used instead of motor alcohol fuels which are of different compositions. No attempt was made to increase the heating value of the fuel by the addition of ether, gasoline or kerosene. The engines used were of commercial tractor types and included 2 rated at 15 to 30 horsepower, 1 rated at 15 to 25 horsepower, and 1 rated at 10 to 20 horsepower.

The dynamometer used was of the hydraulic type and could absorb a maximum of 150 horsepower at from 1,200 to 4,000 revolutions per minute. Observations were made of temperatures of all controlling factors, fuel consumption and brake thermal efficiencies.

Water injection was found beneficial in tractors of the McCormick-Deering type when either gasoline or kerosene was used. The consumption was very much reduced from beginning half-load to as high as the engine could develop. Injection of water increased the volumetric efficiency and lowered the radiator temperature at these loads. The maximum power developed was increased, and knocking due to overheating of the engine was minimized. More injection water was consumed per brake-horsepower-hour when using gasoline than when using kerosene. The use of injection water is recommended for Cletrac "K" and Fordson types from about half-load to normal capacity using gasoline and kerosene.

The experiments also proved that tractor engines originally designed to run with gasoline or kerosene can also be run with straight alcohol of different strengths and with diluted and undiluted denatured alcohol.

With the exception of the Fordson tractor, enlargement of the carburetor jet was found necessary in all tests using alcohol to admit enough fuel to carry the load. This extra fuel was needed because the compression ratio was not increased, and no additional substance was added to the alcohol to increase its heating value.

Some tests showed that at or near the maximum load, the ignition points were retarded a few degrees from the maximum position to get the best running condition and most economical consumption. The point of ignition at which the best tests were made on a certain load was a little earlier for alcohol fuels than for either gasoline or kerosene.

The consumption of fuel per brake-horsepower-hour was greater for alcohol fuels than for either gasoline or kerosene. The higher the percentage of alcohol the less was the consumption per given load. The most economical points for gasoline and kerosene were between three-quarters load and the full normal capacity. For alcohol fuels the points were at the normal load or at the point where the maximum power is developed. In general, the consumption of fuel in pounds per brake-horsepower-hour was greater as the load decreased from the normal rating. A difference of consumption was noted between a new and an old engine of the same type. The difference in consumption between the new and the old 15-30 McCormick-Deering tractor varied from about 17 per cent at half load to 28 per cent at full load. The Cletrac tractor was the only tractor where the equivalent amount of alcohol, in terms of gasoline, decreased as the load increased. The maximum power that could be developed using alcohol was materially higher than that which could be developed using either gasoline or kerosene, and the relative brake thermal efficiencies also were generally higher.

Fuel consumption could be increased by improper fuel needle valve setting, and the possibility of this was greater with alcohol than with the other fuels. Operation with alcohol fuel in these types of engines was characterized by smooth running, steady pull and absence of overheating, preignition, knocking or violent hammering. No sign of corrosion was noted.

Ample provision should be made to atomize, distribute uniformly and vaporize the incoming fresh charge of alcohol. External heating of alcohol alone before it is mixed with air may prove beneficial. Overheating of the fresh mixture in the induction pipe may result in a decrease of volumetric efficiency.

Bending Tests on Dowelled Wooden Beams [trans. title], O. Graf (Bauingenieur, 11 (1930), No. 10, pp. 157-160, figs. 21; abs. in [Great Britain] Department of Science and Industrial Research (London), Building Science Abstracts, n. ser., 3 (1930), No. 4, p. 134).—An illustrated description is given of bending tests conducted at the Technical Academy of Stuttgart, Germany, to compare the deflections of dowelled beams under given loads with those of solid beams of the same dimensions and similar wood, and to determine the ultimate strength of such beams and of dowelled connections.

The data obtained are presented in tabular and graphic form, and the condition of some of the beams after failure is shown by photographs. The deflection of the dowelled was always greater than that of the corresponding solid beams, and the ultimate strength of the former varied between 78 and 96 per cent of that of the latter. In no case was failure due to shearing of the dowells.

[Agricultural Engineering Investigations at the Pennsylvania Station] (Pennsylvania Station (State College) Bulletin 266 (1931), pp. 10-12, figs. 3).—In studies of accessories for plowing in stony ground, R. U. Blasingame found that steel moldboards for tractor plows are more economical because cast moldboards break too often. Cast shares are more economical than steel if an efficient spring release hitch is provided. Two-bottom tractor plows are more satisfactory than a greater number of bottoms, due to the fact that the 2-bottom plow has more flexibility and less breakage.

In potato production experiments using only mechanical power, the man-hours required to grow an acre of potatoes up to harvest were reduced from 48.9 hours when teams were used to 9.59 hours when the general-purpose tractor was used.

Experiments on the adaptation of the general-purpose tractor and the corresponding equipment to corn production indicated that corn can be successfully and economically grown by this procedure. Spring-tooth cultivators have been found to be durable and efficient in land where tight stones occur, but the potato type of weeder is too severe for the corn plant. A more flexible weeder does good work in destroying small weeds and leveling the land to prevent washing of the soil between the rows.

The results of studies of the electrical refrigeration requirements for Pennsylvania dairy farms are reported by J. E. Nicholas.

The Comparative Strength of Short Wooden Beams With and Without Overhang Beyond the Supports, F. J. Converse (American Society of Testing Materials Proceedings, 30 (1930), pt. 2, pp. 1006-1011, figs. 4).—In an investigation carried out at the California Institute of Technology, to determine whether the resistance of a wood beam to longitudinal shear is influenced by the length of overhang of the beam beyond the supports, test specimens of various lengths, with sections ranging from 1.62 to 2.25 inches wide and 1.80 to 3.53 inches deep were tested by loads applied near to the centers of spans ranging from 9 to 16 inches, some with negligible overhangs, and others with overhangs ranging from 5 to 7 inches. The woods tested were Douglas fir, spruce, redwood, and oak.

It was found that in all cases where load is applied parallel to the grain of the wood, and is so distributed as to prevent crushing of the fibers under the load and at the supports, overhang has but little effect upon strength in shear. Where much crushing occurs at supports and beneath the load, the breaking load is in general higher for beams with overhang than for those without. The elastic line of short beams with overhanging ends reverses its direction of curvature near the inside edge of the supports and becomes concave downwards for a short distance before becoming a straight line in the overhanging portions of the beam.

Tests of Welds, W. M. Wilson (Illinois University, Engineering Experiment Station (Urbana) Circular 21 (1930), pp. 37, figs. 22).—The results of tests of electric arc and hand welds of thin steel plates are used in the fabrication of tanks for storage of oil and water reported.

Of the welds tested, the V type seems to be the best for making butt joints in 0.5-inch plates. Six specimens were made from each of 11 kinds of uncoated weld rods. The lowest average strength for any one set of 6 specimens was 50,531 and the average for the 66 specimens 54,410 pounds per square inch.

Specimens made from three rods designed to produce a reduc-

ing atmosphere over the molten metal had ultimate strengths of 76,621, 67,979 and 52,102 pounds per square inch, respectively. The strength of the all-weld specimens made of uncoated rods was 57,500 pounds when the beads were laid longitudinally with the specimens, and 43,314 pounds when the beads were laid transversely to the specimens. The corresponding values for covered rods were 57,300 and 52,375 pounds per square inch, respectively.

Results are also given for elongation in 8 inches and for the modulus of elasticity in pounds per square inch. Six specimens containing lap joints welded with uncovered rods all broke outside the weld, the average strength being 57,605 pounds per square inch, a value just slightly greater than the strength of the control specimens cut from the plates.

The Moisture Equivalent as a Measure of the Field Capacity of Soils, F. J. Veihmeyer and A. H. Hendrickson (Soil Science (Baltimore), 32 (1931), No. 3, pp. 181-193, figs. 6).—In a contribution from the California Experiment Station, data are reported which indicate that the moisture equivalent is a close measure of the field capacities of fine-textured soils for moisture, but not always of sandy soils. The moisture equivalent can be used to indicate the field capacities of deep, drained soils with no decided changes in texture or structure, with moisture equivalents ranging from about 30 per cent down to about 12 or 14 per cent. Below from 12 to 14 per cent, the moisture equivalent seems to be less than the field capacity. Inasmuch as the structure of the soil has also been shown to influence markedly the field capacity, this factor must likewise be considered in using such measurements.

The moisture equivalent seems to give a single-value determination closely related to texture, at least for the fine-textured soils, in spite of the fact that the structure of the sample used in making the moisture equivalent determination may be changed from that found in the field.

The ratios of moisture equivalent to permanent wilting percentage for more than 60 soils ranged from 1.4 to 3.8. Both high and low ratios were found with sands as well as with clays. The results also show that the moisture equivalent is a relative measure of the moisture-holding capacity of fine-textured soils.

Further data show that the moisture content of soil from 2 to 3 days after irrigation does not change materially in the next few days. It is concluded that there is a rather definite soil moisture content which, if measured within 2 or 3 days after a rain or an irrigation, may be assumed to be the field capacity, if there are no discontinuities in structure or texture present and in the absence of a water table.

A list of 24 references to other work bearing on the subject is included.

Farm Underdrainage, F. L. Ferguson (Ontario Department of Agriculture (Toronto, Can.) Bulletin 360 (1931), pp. 16, figs. 15).—Practical information is given on the planning and construction of underdrainage systems, together with materials and unit costs for several different systems, including the herringbone and gridiron.

Wheel and Crawler Type Tractors in Agriculture, Deubel (Fortschritte Landwirtschaft (Berlin) 16 (1931), No. 19, pp. 618—622, figs. 2).—An analysis is given of the draft and other power requirements of German agriculture for the purpose of establishing the economic place of the tractor therein. An analysis of the use of the general-purpose farm tractor shows that to fully utilize a general-purpose tractor on 100 hectares (about 250 acres) it is necessary that fields and meadows be close together and that both be close to the farm home. Where 300 hectares are cultivated the analysis indicates the need for two tractors.

Book Review

"RUSSIA — Market or Menace?" is the conundrum propounded to America by Thomas D. Campbell, wheat industrialist and engineer, after two visits to the Soviet Republics as an advisor on their agricultural program. He does not answer it dogmatically but combines a narrative of his trips and what he actually saw with an explanation of what he learned about the Soviet program of socialization, production, economic and social advancement, education and atheism. A capitalist at heart, but apparently unbiased, he calls attention to both the strong and the weak points in the development. In brief he believes that the program is constructive and progressive for the country and conditions to which it is applied; that it will be modified to strengthen its weak points as they are discovered through experience; that it does not menace world peace, trade or Christianity; that the country will continue to meet its obligations; that it will dump products on world markets at low prices only as it is forced to by foreign bankers withholding credit for its continued imports; that it wants to do business with the United States; that the United States can, and should "through business cooperation, proper sympathy and fair criticism," help the many millions of that country to peace and happiness. Cloth, 5½x8 inches, X + 148 pages, 8 illustrations, 3 maps. Longmans, Green and Company. $2.00.

"Farm Gas Engines and Tractors," a text and reference by Fred R. Jones, associate professor of agricultural engineering, A. and M. College of Texas, is a new addition to the McGraw-Hill publications in agricultural engineering edited by Daniels Scoates. It aims to present its information in detailed but elementary and non-technical form; to give a thorough understanding of gas-engine fundamentals before attempting to cover the more complicated tractor mechanism; and to include such related subjects as power transmission, materials of construction, and utilization of power. The parts and chapter headings are as follows: **Part I. Farm Gas Engines:** Power on the Farm—Sources and Utilization, History of the Internal Combustion Engine, Make-Up of a Simple Gas Engine—Nomenclature and Definitions, Principles of Operation, Engine Types — Engine Speeds — Piston Displacement — Compression, Valve and Valve Operation, Fuels and Combustion, Fuel Supply and Carburetion Systems, Cooling and Cooling Systems, Governing and Governing Systems, Ignition and Ignition Methods, Electrical Ignition —Sources of Electricity, Secondary or Storage Cells, Magnets and Magnetism—Induction, Battery Ignition Systems, Mechanical Generation of Electricity—Magnetos, Lubrication and Lubricating Systems, Power and Its Measurement — Fuel Consumption — Engine Efficiency, Gas Engine Troubles, Materials of Construction — Power Transmission. **Part II. Tractors:** History and Development of the Farm Tractor, Tractor Types — General Make-up of a Tractor, Tractor-Engine Types and Construction—Valve Operation, Tractor Fuel Supply and Carburetion, Air Cleaners, Governing, Cooling Systems, Tractor Ignition, Tractor Lubrication, Clutches, Transmissions — Differentials — Final Drives — Belt Pulleys — Power Take-Off, Tractor Chassis — Frames — Traction Devices — Steering Mechanisms, Tractor Power Transmission — Ratings — Pulley and Belt Speeds — Drawbars — Nebraska Tests, Tractor Care and Operation — Hitches and Field Work — Tractor Troubles — Overhauling, All-Purpose Tractors — Garden Tractors, Economics and Selection of the Farm Tractor. References at end of each chapter. Cloth, 6x9 inches, X + 485 pages, 503 figures, XLVI tables, indexed. McGraw-Hill Book Co. $3.75.

"Land Drainage," by Wilbur L. Powers and Thomas A. H. Teeter, one of the books in the Wiley Agricultural Engineering Series edited by J. Brownlee Davidson, has been revised, enlarged and published in the second edition. The first edition was published in 1922. A few new chapters have been included, and the old chapters brought up to date with new information and illustrations. The parts and chapter headings are as follows: **Part I.—Field Drainage,** Development, Importance and Future of Drainage; Benefits of Drainage; Relation of Soil to Drainage; Relation of Soil Water to Drainage; Types of Drains and their Location; Materials for Covered Drains; Depth and Frequency of Tiles; Measurement of Drainage-Water; Size and Grade for Tiles; Construction of Underdrains; Costs and Profits of Tile-Drainage; Development of Wet Land. **Part II.—District Drainage,** Drainage Districts and Drainage Laws; Assessments of Drainage Benefits and Costs; Large Tiles vs. Open Ditches; Design, Construction and Maintenance of Open Ditches; Flood Control (new); Estimates of Costs of Large Drainage Systems. **Part III.—Special Drainage Problems,** The Drainage of Tidal and Overflowed Marsh Lands; The Drainage of Irrigated Lands; Drainage by Means of Pumping from Wells (new); Prevention and Control of Erosion, with Special Reference to Terracing (new); Miscellaneous Drainage Problems. **Part IV.—Drainage Surveying,** Drainage Surveying and Practice. Appendixes on "Farm Drainage Laboratory Exercises," "Tables for Use in Kutter's Formula" and "U. S. Census of Drainage—1930" are included. Cloth, 6x9 inches, 353 pages, 169 figures, indexed. John Wiley and Sons. $3.25.

"You Can Make It for Profit," by H. Conrad Hoover, is the third of a "You Can Make It" series of bulletins published by the National Committee on Wood Utilization. It gives information on the construction of numerous marketable, small, wood articles for use in or about the home, including some general paragraphs on materials, tools, methods, marketing, American lumber standards, etc. Available from the Superintendent of Documents, Washington, D. C., at 10 cents per copy.

"Jobs for the College Graduate in Science" is a professional guidance book by Edward J. V. K. Menge, for the information of high school and college students and their parents. For clarity and convenience the pure and applied sciences and opportunities they offer are classified and presented in I. The Mathematicians, The Physical and Chemical Group; II. The Medical Group; III. Engineering; and IV. The Biological Sciences. Dr. Menge has obtained from the headquarters of each of the representative professional societies for 36 professions under the above groupings, information on the work of the profession; the number of individuals in it; their approximate incomes, qualifications, and training; the opportunities in endowed research institutes, government positions, consulting work, etc.; the professional organization itself; and books to consult for more detailed information. Unfortunately and incorrectly the address of the American Society of Agricultural Engineers is given as St. Joseph, Missouri, rather than St. Joseph, Michigan. Cloth, 175 pages, 5½ x 8 inches, indexed. Bruce Publishing Co. $2.00.

AGRICULTURAL ENGINEERING

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Contributions of interest and value, especially on new developments in the field of agricultural engineering, are invited for publication in this journal. Its columns are open for discussions on all phases of agricultural engineering. Communications on subjects of timely interest to agricultural engineers, or comments on the contents of this journal or the activities of the Society, are also welcome.

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Raymond Olney, Editor
R. A. Palmer, Associate Editor

A Great Annual Meeting

GREAT philosophers have said repeatedly that it takes adversity to bring out the best in men. Examples of this truth are too familiar to require citation.

The current adversities with which agriculture and its related industries are faced are decidedly personal to agricultural engineers. Annual meetings of the American Society of Agricultural Engineers have always been notable for the evident earnestness of purpose of those present. This year it will be more apparent than ever. The program commands serious attention. Many will make considerable sacrifices to be present. All will be quickened by unusual consciousness of their professional and personal responsibilities and opportunities.

As one well-known agricultural engineer has put it, "The present general economic upheaval is probably due quite largely to the fact that in applying science to industry, we have failed to give due consideration to collateral or secondary results. However, we surely cannot expect to find a satisfactory remedy by discarding science." The meeting program has been designed to direct attention to these collateral results, or, as President Leonard J. Fletcher calls them, "higher values." It has also been designed to encourage discussion. Dr. E. A. White, chairman of the Meetings Committee, says, " . . . . . many of the subjects to be presented afford ample opportunity for difference of opinion, interpretation of facts as to future tendencies, and the expression of ideas as to the policies of the engineer for agricultural development. Look the subjects over. Come to the meeting prepared to express well-thought-out ideas in concise understandable form."

The session on "an engineer's policy for agriculture," for example, warrants some intense, unprejudiced, advance concentration on such questions as: (1) What degree of material welfare may be most conducive to the social welfare, progress, and happiness of farm people? (2) What are agriculture's obligations as to the quality and cost of the products it furnishes to the non-agricultural population? (3) How great an increase in production efficiency may be necessary to achieve these ideals of material welfare, quality, and production cost? (4) What are the possibilities of raising individual farm efficiency to this standard by changes in farm practice, organization, scale of operations, biological working material, amount of processing done, and engineering control of operating conditions? (5) What should be the influence of national, long-time considerations such as conservation of natural resources, land reclamation, foreign competition and world trade, synthetic foods and fibers, consumption of agricultural products in the chemical industries, etc.? (6) What ratio of farm population to total population does the projected standard of welfare and production efficiency imply? (7) How and how rapidly can any necessary adaptation of submarginal farmers to other occupations be made? (8) What of the pressure to move surplus industrial workers from the city onto small farms? (9) What other social adjustments may increasing farm efficiency require, and how can they be made with least friction?

Yes, it will be a great meeting, with the combined environment and facilities of a large city, state university, agricultural college, and agricultural engineering department, surrounded by good farm country; a timely program of interesting and constructive addresses, reports, and entertainment, carefully scheduled to avoid conflicts, crowding of events, or waste of time; and valuable contact opportunities, information and inspiration for all, from students up to engineering executives. A meeting matched to the challenge of the times.

Research in the Natural and Social Sciences of Agriculture

EDITORIAL comment in the March issue of the "Experiment Station Record," published by the U. S. Department of Agriculture, points out that coincident with a generally increasing quality of rural economic and sociological research, and emphasized by world-wide depression, has come recognition of a need for more comprehensive programs of research. Problems in these fields are often regional, national and international as well as local; interrelated as well as individual. An example cited of the type of research referred to is a 3-year study just started, of interrelated farm and home, educational and rural life problems in the Southern Appalachian Highlands.

To further clarify the point the editorial quotes from an address by Director W. C. Coffey of the Minnesota Agricultural Experiment Station as follows: "On the one hand our agriculture needs a science to make us intelligent and efficient in our processes of production; on the other hand, it needs a science to make us intelligent and efficient in distributing our production and adjusting it to the logical demand for it. If the amount of production greatly exceeds the demand for it, interest in intelligent and efficient production and the science underlying it is sure to sag. If production should be unintelligent and inefficient, no system of distributing and adjusting production to demand could bring prosperity and better living to rural people. In these very simple terms, the essential relationship between the natural and social sciences in agriculture may be expressed."

As compared to the traditional and recognized ideas and ideals of intelligent and efficient agricultural production, the views of many agricultural engineers have been decidedly unorthodox. Furthermore, there has been a wide disparity of opinion on the economic and social implications of efficient agricultural production.

Agricultural engineering research has provided data on current and possible efficiencies of specific operations and programs of farm production. It has supported agricultural-engineering theory on the possibilities of increasing farm-production efficiency. The new, large-scale, correlated research referred to above should likewise provide data which will clarify viewpoints on the social and economic significance of increasing efficiency, either vindicating or discrediting the heterodox views of some agricultural engineers. When the conservative and progressive viewpoints are thus brought closer together by new knowledge, all agricultural workers will be able to work together more effectively to facilitate the necessary readjustments, be they great or small.

A.S.A.E. and Related Activities

A.S.A.E. Annual Meeting Program

Ohio State University, Columbus, Ohio — June 20, 21, 22, and 23, 1932

First Day — Monday, June 20

Forenoon Program—9:00 to 12:00

COLLEGE DIVISION SESSION

Charles E. Seitz, chairman, presiding

1. Reports of Committees
   - Cooperative Relations with Industries—J. B. Davidson, chairman
   - Agricultural Engineering Teaching—C. O. Reed, chairman
   - Agricultural Engineering Research—E. E. Brackett, chairman
   - Agricultural Engineering Extension—Geo. Amundson, chairman
   - Student Branches — V. R. Hillman, chairman
   - Relations with Vocational Education—M. A. Sharp, chairman
   - Publication Standards—D. G. Carter, chairman
2. ADDRESS: "The Place of the Agricultural Engineer in Agricultural Extension Work" — R. J. Baldwin, director of agricultural extension, Michigan State College
3. Business Session

Afternoon Program—2:00 to 5:00

COLLEGE DIVISION SESSION

Elmer E. Brackett, presiding

1. ADDRESS: "Relation of Commercial Extension to College Extension Work in Agricultural Engineering"—Geo. Amundson, extension engineer, Michigan State College
2. ADDRESS: "Agricultural Engineering Research in Cooperation with Other College Departments" — Ben D. Moses, associate agricultural engineer, California Agricultural Experiment Station
3. ADDRESS: "The Place of the Agricultural Engineer in the Agricultural Experiment Station" — (Speaker to be selected)
4. ADDRESS: "The Logical Future Development of Research in Agricultural Engineering"—R. W. Trullinger, assistant in experiment station administration (senior agricultural engineer), Office of Experiment Stations, U. S. Department of Agriculture

STUDENT GROUP SESSION

(Program in process of development)

Evening—Special Group Sessions

1. (6:00 p.m.) 1932-33 Meetings Committee Dinner and Conference
2. (6:00 p.m.) College and Commercial Extension Workers' Session
   - (a) Purpose of the Joint Extension Committee—S. P. Lyle
   - (b) Cooperation in Extension Programs—I. D. Wood and L. F. Livingston
   - (c) General discussion
3. Student Group Session

   Aldert Molenaar, chairman, presiding
   - (a) Reports from A.S.A.E. student branches represented
   - (b) Paper: "Research in Refrigeration of Milk"—R. G. Bressler, graduate student in agricultural engineering, Pennsylvania State College
   - (c) Address: "The Agricultural Engineer — His Opportunity for Service" — Chas. E. Seitz, chairman, A.S.A.E. College Division
   - (d) Address: "Tomorrow's Job for the Agricultural Engineer" — Leonard J. Fletcher, president, A.S.A.E.
   - (e) General discussion

Second Day — Tuesday, June 21

Forenoon Program — 9:00 to 12:00

GENERAL SESSION

Leonard J. Fletcher, president, presiding

1. Meeting called to order—G. W. McCuen, chairman, Committee on Local Arrangements
2. Address of Welcome—Dr. George W. Rightmire, president, Ohio State University
3. President's Annual Address—Leonard J. Fletcher, agricultural engineer, general supervisor of agricultural sales, Caterpillar Tractor Company
4. ADDRESS: "Some Economic Aspects of an Engineered Agriculture" — M. L. Wilson, professor of agricultural economics, Montana State College
5. PAPER: "Artificial Drying of Agricultural Products" — R. B. Gray, chief, division of mechanical equipment, Bureau of Agricultural Engineering, U. S. Department of Agriculture
6. PAPER: "Fertilizer Application for Corn Production"—C. O. Reed, professor of agricultural engineering, Ohio State University

Afternoon Programs (1st period) 1:30 to 3:15

JOINT SESSION — POWER AND MACHINERY DIVISION AND RURAL ELECTRIC DIVISION

G. W. McCuen and G. W. Kable, chairmen, presiding

1. ADDRESS: "Adventures in Science"—L. A. Hawkins, executive engineer, research laboratories, General Electric Company
2. PAPER: "Interpretation of the Index System for Testing Fineness of Material"—E. A. Silver, research agricultural engineer, Ohio State University

STRUCTURES DIVISION SESSION

Henry Giese, vice-chairman, presiding

1. REPORT: "Dairy Barn Standards"—J. L. Strahan, consulting agricultural engineer
2. PAPER: "Aluminum Paints As Protective Coatings" — W. B. Roberts, Aluminum Company of America

Afternoon Programs (2nd period) 3:15 to 5:00

LAND RECLAMATION DIVISION SESSION

W. W. McLaughlin, chairman, presiding

1. Reports of Technical Committees

RURAL ELECTRIC DIVISION SESSION

Geo. W. Kable, chairman, presiding

1. SYMPOSIUM: "Electric Hotbeds and Soil Heating," sponsored by the Committee on Soil Heating—B. D. Moses (chairman), F. E. Price, J. C. Scott, D. E. Blandy, and M. W. Nixon

STRUCTURES DIVISION SESSION

Henry Giese, vice-chairman, presiding

1. REPORT: "Cooperative Plan Service"—S. P. Lyle, senior agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture
2. REPORT: "Dairy Manger Standards" M.A.R. Kelley, agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture
3. PAPER: "Dairy Barn Studies"—H. B. White, agricultural engineer, University of Minnesota

Third Day — Wednesday, June 22

Forenoon Program—9:00 to 12:00

GENERAL SESSION

Leonard J. Fletcher, president, presiding

1. SYMPOSIUM: "An Engineer's Policy for Agriculture"—
   - (a) Arthur Huntington, public relations engineer, Iowa Railway and Light Corporation
   - (b) J. T. Jardine, chief, Office of Experiment Stations, U. S. Department of Agriculture
   - (c) C. F. Kettering, president, General Motors Research Corporation

Afternoon Programs (1st period) 1:30 to 3:15

JOINT SESSION—RURAL ELECTRIC DIVISION AND STRUCTURES DIVISION

G. W. Kable and W. C. Harrington, chairmen, presiding

1. PAPER: "Ventilation of Animal Shelters"—F. L. Fairbanks, assistant professor of agricultural engineering, Cornell University
2. REPORT: "New Developments in Farm Wiring," Joint Committee on Farm Wiring — E. R. Meacham (chairman), R. E. Hayman, C. P. Wagner, W. C. Krueger, and F. B. Wright
3. REPORT: "Dairy Refrigeration Equipment," H. W. Riley, professor of agricultural engineering, Cornell University

POWER AND MACHINERY DIVISION SESSION

G. W. McCuen, chairman, presiding

1. PAPER: "Handling Straw from the Combine" — F. P. Hanson, agricultural engineer, Caterpillar Tractor Company
2. PAPER: "Physical Properties of Soils of Interest to Agricultural Engineers"—Dr. L. D. Baver, associate professor of soils, University of Missouri.
3. PAPER: "Efficiency of Tractor Spark Arresters"—Roy Balner, agricultural engineer, University of California

Afternoon Programs (2nd period) 3:15 to 5:00

POWER AND MACHINERY DIVISION SESSION

W. L. Zink, vice-chairman, presiding

1. PAPER: "Fuels for High-Compression Motors"—Thomas Midgley, Jr., special lecturer, department of chemistry, Ohio State University
2. PAPER: "Corn Production Costs by Mechanical Methods under Federal Clean-Up Regulations"—R. H. Wileman, agricultural engineer, Purdue University

LAND RECLAMATION DIVISION SESSION

W. W. McLaughlin, chairman, presiding

1. PAPER: "Agricultural Drainage in Ohio" — Virgil Overholt, professor of agricultural engineering, Ohio State University.
2. PAPER: "Land Reclamation in the Great Lakes Region"—H. H. Musselman, professor of agricultural engineering, Michigan State College
3. PAPER: "Progress of Irrigation in Eastern United States" — F. E. Staebner, associate drainage engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture
4. PAPER: "The Refinancing of Drainage Districts" — George R. Boyd, senior drainage engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture
5. PAPER: "Irrigation and Drainage of Recreational Grounds"—Wendell P. Miller, consulting agricultural engineer

Evening Program—7:00 to 9:00

ANNUAL BANQUET

Daniel Seltzer, toastmaster

1. ADDRESS: "An Agricultural Engineer's Observations in Russia" (illustrated)—E. J. Stirniman, agricultural engineer, formerly associate professor of agricultural engineering, University of California; later agricultural engineer, Graintrust, U.S.S.R.

Fourth Day — Thursday, June 23

Forenoon Program—9:00 to 12:00

GENERAL SESSION

Leonard J. Fletcher, president, presiding

1. PAPER: "Recent Developments in Land Reclamation" — L. A. Jones, chief, division of drainage and erosion control, Bureau of Agricultural Engineering, U. S. Department of Agriculture
2. ADDRESS: "How the Farmer Looks at the Engineer"—M. S. Winder, secretary, American Farm Bureau Federation
3. PAPER: "Specific Example of a Planned Engineered Agriculture — F. W. Duffee, professor of agricultural engineering, University of Wisconsin
4. Awarding of the Cyrus Hall McCormick Medal (tentative)

Afternoon Programs (1st period) 1:30 to 3:15

JOINT SESSION — POWER AND MACHINERY DIVISION AND LAND RECLAMATION DIVISION

G. W. McCuen and W. W. McLaughlin, chairmen, presiding

1. PAPER: "Operation of Power Machinery on Terraced Land"—R. W. Baird, associate agricultural engineer, U. S. Department of Agriculture
2. ADDRESS: Dr. Elwood Mead, Commissioner of Reclamation, U. S. Department of the Interior

RURAL ELECTRIC DIVISION SESSION

G. W. Kable, chairman, presiding

1. SYMPOSIUM: "Productive Uses of Light in Agriculture," Committee on Productive Use of Light — K. M. Reid (chairman), Hobart Beresford, W. C. Krueger

Afternoon Programs (2nd period) 3:15 to 5:00

JOINT SESSION — POWER AND MACHINERY DIVISION AND LAND RECLAMATION DIVISION

G. W. McCuen and W. W. McLaughlin, chairmen, presiding

1. PAPER: "Ditch Cleaning and Ditching Machinery"—W. D. Ellison, assistant drainage engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture
2. PAPER: "Influence of Irrigation Farming on Machinery Design" — W. L. Paul, machine designer, John Deere Plow Works

RURAL ELECTRIC DIVISION SESSION

G. W. Kable, chairman, presiding

1. FORUM: Discussion of Various Problems in the Engineering Development of Farm Electrification—
   (a) "Economics of the Electric Motor for Belt-Driven Machines," Committee on Electric Motors—Ralph Prater (chairman), G. A. Rietz, W. D. Hemker, and C. L. East
   (b) "Status of the Stationary Spray Plant"—H. L. Garver, rural electrification investigator, State College of Washington
   (c) "A 10-Gallon Electric Milk Sterilizer" — H. E. Besley, assistant agricultural engineer, Maryland Agricultural Experiment Station

A.S.A.E. Officers, 1932-33

NEW officers chosen by the Society in its regular annual election and to take office during the twenty-sixth annual meeting, at Columbus, are as follows:

President ..... C. E. Seitz
First vice-president ..... W. W. McLaughlin
Second vice-president ..... R. W. Carpenter
Councilor ..... Hobart Beresford

The new Council includes the above officers together with the following:
Councilor ..... L. A. Jones
Councilor ..... Theo Brown
Treasurer ..... Raymond Olney
Senior past-president ..... R. W. Trullinger
Junior past-president .. L. J. Fletcher

S. H. McCrory, chairman, L. W. Chase, and F. C. Fenton are the newly elected nominating committee.

Advisory Committee Election Results

B. D. MOSES and J. C. Wooley are the new elective members of the Advisory Committee of the College Division. They will take their places on the Committee following the June meeting. The other members of the Committee whose terms do not expire until June 1933 are G. W. McCuen and E. R. Gross.

Committee on Fuels and Lubricants Travels

THREE members of the A.S.A.E. Committee on Fuels and Lubricants, namely chairman R. B. Gray, chief of the division of mechanical equipment, U.S.D.A. Bureau of Agricultural Engineering; vice-chairman C. G. Krieger, Jr., Ethyl Gasoline Corporation; and William Harrigan, The Texas Company, started a two-weeks' trip at Canton, Ohio, April 25.

They visited tractor and farm engine manufacturers in Ohio, Michigan, Wisconsin, Illinois and Iowa to discuss the possibilities of improvements in performance and efficiency, and to encourage experiments with various combinations of compression pressures, lubricants and petroleum fuels.

The objective of the committee's whole program is to promote interest and action, on the part of the manufacturers and oil refiners, toward the more economic operation of tractors and farm engines.

New ASAE Members

E. J. Hergenroether, metallurgist, The International Nickel Company, Inc., 4-117 General Motors Building, Detroit, Mich.

John Lowe, assistant architect, Architects Office, Department of Agriculture, Central Experimental Farm, Ottawa, Canada.

Hugh C. E. Peterson, agricultural engineer to the government of Bengal, Dacca, India.

Transfer of Grade

P. C. McGrew, agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture, State College of Washington, Pullman, Wash. (Assoc. to Member)

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the April issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Merrill B. Cann, vice-president, Esco Cabinet Co., 140 E. Market St., West Chester, Pa.

Professor Dr.-Ing. C. H. Dencker, head of the department of agricultural engineering, Landmaschineninstitut Landsberg (Warthe) Germany.

R. Pardow Hooper, consulting agriculturist and farm appraiser, 114 Sansome St., San Francisco, Calif.

Lewis M. McGhee, agricultural engineer, Appalachian Electric Power Company, 523 Main St., Lynchburg, Va.

John E. Nicholas, associate professor, department of agricultural engineering, Pennsylvania State College, State College, Pa.

Marvin F. Schweers, extension agricultural engineer, Agricultural Engineering Extension, Michigan State College, East Lansing, Mich.

EMPLOYMENT BULLETIN

Men Available

AGRICULTURAL ENGINEER, now employed, desires change of location. Graduate of middle western institutions with B.S. and M.S. degrees in agricultural engineering. Will accept either teaching, extension or commercial position. MA-210.

AGRICULTURAL ENGINEER, graduate of Iowa State College, desires to contact manufacturer selling the farm market, or who wants to develop or expand agricultural sales department. Six years' experience in sales promotion, advertising and publicity in tractor, farm implement, and building material industries. Age 29. MA-212.

AGRICULTURAL ENGINEER, with bachelor's degree in agricultural engineering from Virginia Polytechnic Institute (1929) and master's degree from University of Maryland (1931) and with two years research experience in rural electrification and two summers extension work in farm water supply, desires position in rural electrification extension work or research. Age 23. Single. MA-213.

SUPERINTENDENT OF TRANSPORTATION, with successful record in handling transportation and civil engineering problems on sugar properties, has also handled public relations and dealings with the War Department and police juries regarding permits, etc., practical man who adapts himself well to any conditions and understands the working class in the tropics or the states. Now employed. Available May 15. Age 30. Married. Will go anywhere, but prefers the tropics. MA-214.